Wheat Protein Conference

Agricultural Research Manual
Science and Education Administration
U.S. Department of Agriculture

ARM-9
October 1979

LCCN 79-600180

WHEAT PROTEIN CONFERENCE

Manhattan, Kansas

October 16-17, 1978

Sponsored by

American Bakers Association
American Institute of Baking
Crop Quality Council
Kansas State University
Millers National Federation
National Association of Wheat Growers
Wheat Quality Council
and the
U.S. Department of Agriculture
Science and Education Administration

Published by Agricultural Research (North Central Region)
Science and Education Administration, U.S. Department of Agriculture
Peoria, Illinois 61615

CONTENTS

Introduction

Wheat protein identity, function, and significance are some of the many aspects discussed at the Wheat Protein Conference in Manhattan, Kans., October 16-17, 1978. Participants included bakers, breeders, producers, millers, exporters, researchers, economists, and merchants.

In the first session, a history was presented of wheat grown throughout the Great Plains, including a discussion of current challenges associated with providing more and better protein from high quality wheat and with enhancing the production of consumer-acceptable food. A private breeder discussed protein in the hard red winter wheat area, in the hard red winter wheat developed by a state, and in the hard red spring area; and federal and state breeders discussed research programs to improve high protein content. A baker presented his view of American wheat flour quality in both domestic and international markets.

The second session was devoted to wheat protein functions: what they are, what they do, and what can they be made to do. A wheat grader discussed quality factors in grain marketing, and a producer reviewed wheat production and marketing.

The final session included views by millers on overall wheat quality and its nutritive content for American diets; an exporter's view of U.S. competitiveness in the marketplace; and an economists' analysis of wheat production, marketing, and use.

THE BAKER'S VIEW

Simon S. Jackel[1]

BAKERS GOLD . . . HIGHER FLOUR PROTEIN

INTRODUCTION

This meeting was requested by the baking industry because of a perceived need to halt and reverse the steady deterioration in protein, ash, and baking quality of commercial bakers patent flour.

The request was made in a Position Paper signed by Robert J. Wager and Simon S. Jackel and submitted to the U.S. Department of Agriculture July 26, 1977.

Robert Wager is full-time president of the American Bakers Association. Simon Jackel is chairman of the ABA Technical Liaison Committee with the U.S. Department of Agriculture. Dr. Jackel's full-time position is vice president, laboratory and technical Research, Quality Bakers of America Cooperative, Inc., a group of more than 120 independently owned wholesale bakers, representing an annual volume of sales in excess of $1 billion.

The Position Paper submitted to USDA outlined the problems of deteriorating flour quality and recommended that

> The Department convene a National Conference on Wheat Protein Levels . . . to draw up a national program to improve wheat protein levels . . . . which would serve not only the interest of our industry, but the national interest as well. . . .

The roster of organizations represented on the steering committee that set up this meeting, and the roster of those in attendance, is testimony to the high level of interest in the subject and to the successful efforts of USDA executives Leland Briggle and Wilda Martinez, who made the arrangements.

The importance of this meeting to me is that it is agri-business oriented, cutting across all sectors involved in wheat, flour and bread.

---

[1]Vice president, Laboratory and Technical Research, Quality Bakers of America Cooperative, Inc., 1515 Broadway, New York 10036.

FLOUR:

The baker's most important ingredient.

The opportunity for the producer and his major domestic customer, the baker, to learn how to communicate with each other, for mutual benefit and for benefit of the American consumer, is a first of major significance.

STATEMENT OF THE PROBLEM

A baker has been defined as a person who upgrades flour by converting it into edible merchandise having a high order of universality and desirability. Of course, there are many other possible definitions of what a baker is and does.

The one I have chosen recognizes one very important fact: flour is the most important ingredient with which a baker works. And that is true no matter what standard of measurement is used. Flour is the most important ingredient from the standpoint of quantity, from the standpoint of cost, and from the standpoint of the quality of the finished baked-goods product.

In order to bake top quality breads and rolls, bakers need top-baking quality flour containing a high level of mellow protein. Since flour is so important, the quality of the flour that is available from millers is of continuing concern. In the absence of proper flour, the baker is forced to use crutches--gluten and various additives--and to accept higher levels of cripples and stale returns.

All of these factors add costs which ultimately must be defrayed by the consumer. A recent estimate of this additional and wasteful cost is $72 million per year.

Furthermore, the protein level of flour is needed to maintain the protein content of breads as stated on the nutritional panel. Most enriched white breads and rolls are labeled to provide 8 percent of the U.S. RDA for protein in a 2-ounce serving. When flour contains less than 11.5 percent protein, this claim can be met only by adding such protein supplements as soy flour or gluten.

Not too many years ago we assured ourselves that the quality of available flour was up to the required standards.

1974: RUSSIA entered marketplace, wheat quality declined.

Plenty of good wheat was available, and the mills had the technology to produce high quality flour as well as the laboratory facilities, to make individual adjustments as required by specific bakeries.

We rarely had any heavy problems, and we rarely had occasions to put any heavy pressure on the millers regarding protein levels, or any other measure of flour quality.

But all of this changed in 1974 when the USSR entered the marketplace as a major wheat buyer and cleaned out all of the wheat reserves in the United States. The problem was compounded by the emphasis placed by wheat growers on yield, with lesser concern for baking quality.

Unable to build up stocks of known quality, millers were no longer in a position to give the bakers the same high quality flour that they had in the past. Furthermore, not having access to reserve wheats, they were unable to cope as successfully with many bakery problems as they had done in the past.

This suddenly brought home to many segments of the baking industry the realization that, in truth, flour quality has been slipping steadily for many years, not just recently.

MEASURES OF THE PROBLEM

Protein is a major and key measure of what is happening in flour. The major bakers patent flour, which is supplied to a particular group of more than 80 large wholesale bakeries, is recognized by all national millers under the grade designation QBA BM-2. The descending trend in protein of this flour is clearly detailed in table 1.

TABLE 1

PROTEIN AND ASH OF STANDARD COMMERCIAL BAKERS PATENT FLOURS

CROP YEARS	ACCEPTABLE RANGES PROTEIN	ACCEPTABLE RANGES ASH
1964 to 1967	11.6 – 12.0%	.42 – .45%
1968 to 1972	11.3 – 11.7	.42 – .45
1973 to 1975	11.2 – 11.8	.44 – .47

Patent — consists solely of endosperm

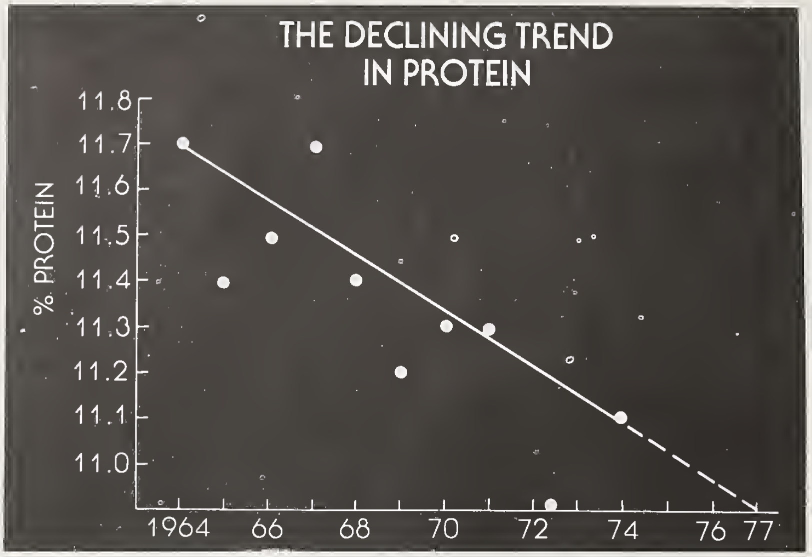


FIGURE 1

Please note that the minimum acceptable protein level, which was 11.6 percent in 1964-1967, fell to 11.3 percent in 1968-1972, and to 11.2 percent in 1973-1975. At the same time, ash values were increasing so that .42 to .45 ash flour, which was the major flour in 1964-1967, became .44 to .47 ash flour as the major flour in 1973-1975. Looking at this differently, please refer to figure 1.

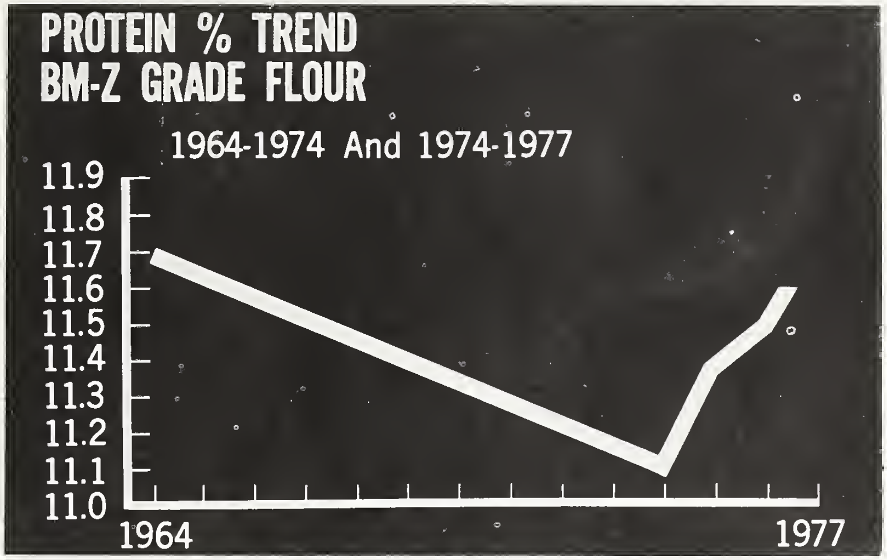
The trend line for protein deterioration shows a steady rate of decline from 11.7 percent in 1964 to 11.1 percent in 1974. Projections at that point revealed that by 1977 protein levels, unless the decline was halted, would deteriorate to 11 percent and even less.

I am sorry to say that this projection came to pass in reality, and that many segments of the baking industry received flour at a protein level of 11 percent and less.

In our group of bakeries, we were so dismayed at this loss of quality that we announced in 1974, when flour protein hit a low of 11.1 percent, that in the future we could no longer accept flour with less than 11.4 percent protein. Please note figure 2 at this point, which shows what happened.

The baking industry must take a strong stand on flour quality.

FIGURE 2



The declining trend was halted in 1974 for our purchases and gradually is climbing back to values we consider necessary for making top-quality breads and rolls at the least cost to the consumer.

For these reasons we feel the baking industry must take a strong stand on flour quality.

Table 2 shows the protein values in flour that we believe are necessary, coupled with superior baking quality, to meet the consumers' requirements for breads of today and tomorrow. This means increasing emphasis on "natural" supplements and decreasing emphasis on supplementing with additives and synthetic chemicals.

At this time we prefer flour with a protein of 11.8 ± .2 percent; eventually we are looking for 12.0 ± .2 percent and possibly still higher. As flour protein levels increase beyond 12.0 percent, the dependence on gluten and other additives becomes increasingly less.

Mixing requirements do not become intolerable because dough strengthening ingredients, which tend to increase mixing requirements, are reduced substantially. At around 13.0 percent protein, the need for dough strengtheners is virtually eliminated.

TABLE 2

PROTEIN CONTENT OF FLOURS	
BM-2 GRADE	11.8% ± .2%
HO-3 GRADE	11.4% ± .2%
EVENTUAL GOAL	12.0% ± .2%

Millers pass on lower protein levels to the baker.

At the present we are accepting 11.4 $\pm$ .2 percent protein levels because we are told this is the most uniform grade with reasonable baking quality, considering year-round availability and geographic distribution.

To highlight the universality of the problem in the baking industry, I would like to show you certain flour measures and trends representing commercial baker's patent flour furnished to a group of 40 to 50 bakeries belonging to a different bakery cooperative.

In the 5 years from 1972 - 1977, the average protein level for this group of bakeries declined from 11.95 percent to 11.33 percent--a decrease of .62 percent, or a 5.4 percent in protein level. Perhaps even more important than these average figures are the lows that were reported for each year. By 1977 the low end of the protein range had declined to just over 11 percent. These bakers were receiving the flour our projections anticipated.

The other side of the coin is ash content, which has been increasing steadily over this same period. Please refer to table 4.

On an average basis, the 5-year change in ash levels rose by more than 14 percent. Bakers tend to feel compromised in their efforts for top quality when ash levels in bakers patent flour approach and exceed .45 or .46 percent.

Simmultaneously, absorption of these flours was declining at an alarming rate as shown in table 5.

TABLE 3

FIVE YEAR PROTEIN RANGE

Year	1972	1973	1974	1975	1976	1977
High	12.30	12.05	11.95	11.55	11.60	11.60
Low	11.60	11.55	11.25	11.35	11.30	11.05
Average	11.95	11.80	11.60	11.45	11.45	11.33

5 Year change –.62%
% Decrease –5.4%

TABLE 4

FIVE YEAR ASH RANGE

Year	1972	1973	1974	1975	1976	1977
High	.430	.433	.455	.472	.478	.493
Low	.408	.425	.433	.455	.461	.466
Average	.419	.429	.444	.463	.469	.479

5year change +.060%

%increase 14.3%

TABLE 5

FARINOGRAPH ABSORTION (Percent)

Year	1972	1973	1974	1975	1976	1977
High	63.5	62.5	62.5	62.0	61.5	61.4
Low	61.0	60.5	61.0	61.0	59.0	57.9
Average	62.0	61.5	61.5	61.5	60.5	59.0

5 year change 3.0%

%decrease 4.8%

Average absorption decreased from 62.0 percent in 1972 to 59.0 percent in 1977. The absorption decrease detected by the Farinograph is reflected by absorption decreases in bakery production experience. This is perceived as a damaging trend because of its potential effect in reducing bread softness and increasing bread firmness.

Another characteristic, light reflection as measured by the Agtron using the green-mode filter, is shown in table 6.

These values measure color characteristics reflecting the pigments present in bran. Lower numbers indicate lesser reflectance and, therefore, darker flours. The values available since 1975 also show continual declines. Note particularly the sizable jump at the low end of the range from 1976 to 1977.

All the while the decrease in wheat protein quality was taking place, the non-baking segments of the agri-business community were, in effect, giving it their blessing. They were operating in the belief that the baker can make dough with any level of protein, no matter how low, just as long as the protein is of good quality. And, furthermore, they believed that bakeries were

TABLE 6

AGTRON VALUES			
Year	1975	1976	1977
High	64	64	65
Low	55	52	48
Average	60	58	57

so profitable that they could afford to pay whatever was necessary for the costly additives and other crutches that were necessary to compensate for the low flour quality.

That philosophy perhaps worked well for the millers, and perhaps worked fine for the wheat growers, but it was working severe hardships on the bakers.

THE NEED TO IMPROVE

We may ask with justification whether it is feasible for the trend to lower protein to be reversed. Is it feasible to ask that wheats be developed and grown that will give the farmers high yields while producing high-protein, top-baking quality flour, as the common non-premium flour for baking? We believe it is and we believe that the state of scientific knowledge is ready for this breakthrough.

I know that this topic will be covered in great detail later in the program by some of the most dedicated and capable geneticists and breeders in the world. I eagerly await their words of encouragement knowing at the same time that this is an objective of major difficulty, requiring skill, dedication, and patience.

This is an important objective. More than half of domestic wheat production is converted into flour for use by the wholesale baking industry. As shown in table 7, over 300 million bushels of wheat become 14 billion pounds of flour, which become 22.4 billion pounds of bakery foods every year of which 75 percent are breads and rolls.

AMERICAN BAKING INDUSTRY'S SHARE OF DOMESTIC WHEAT USAGE. 57.2%

TABLE 7

AMERICAN BAKERS IN 1976 USED:

319.2	MILLION BUSHELS OF WHEAT, CONVERTED INTO
14	BILLION POUNDS OF FLOUR, CONVERTED INTO
22.4	BILLION POUNDS OF BAKERY FOODS, OF WHICH 75% WERE BREADS AND ROLLS.

We believe that returning to higher protein wheats and flours will save bakers up to 30 cents per hundred pounds of flour in lower cripples, rejects and returns, as well as lesser dependence on added gluten. Some bakers who spend $250,000 a year on added gluten, at a cost of 54 to 60 cents a pound, because the flour is too low in protein. This is a real reversal of economics because protein in flour is far more effective than the protein after isolation as gluten.

The baker who uses 20 million pounds of flour annually could foresee potential savings of $60,000 per year. Furthermore, better bread could be made that would remain soft and tasty longer and, would have more consumer appeal than ever before.

If as a result consumers begin to eat more bread, you might see an increase in the national average by one slice a day going from 5 to 6 slices of bread. See table 8.

This seemingly small increase actually would amount to a 20 percent increase in volume and would provide an additional market for more than 60 million bushels of wheat a year, converting into almost 3 billion pounds of flour, which bakes into 4.5 billion pounds of breads and rolls.

Most of our problems with low protein flour trace back to the early 1960's when high bushel per acre yields became the major priority. We are not critical. A hungry emerging world needed to be fed. But now we feel we must return to the search for high-yielding wheat varieties that will also contain high levels of top baking-quality protein.

In the past, when the baking industry brought up the question of low protein flour, we were told that the baker can get by with low flour protein levels if the protein quality is good, and that he can afford to pay premiums for higher protein if he is dissatisfied.

These policies, which we estimate have siphoned $72 million a year out of the baking industry, have hurt bread and roll sales; and the wheat farmer, whose sales of American wheat have been hurt overseas because of low protein levels.

Furthermore, the whole picture is confused by statements from Kansas Wheat Growers that under the present system, do not benefit from premium payments for higher protein because the premiums do not reach them. On this basis, they seem to be indifferent to the issue of protein level and protein quality.

The big question is whether we can get high bushel-per-acre-yields to satisfy the farmer while, at the same time, achieve high levels of superior baking quality protein. We are hopeful and optimistic that just as wheat varieties were bred for high yields, they can now be bred to produce the necessary high protein levels.

WHAT WE HOPE FOR

We hope that this conference of wheat producers, millers, bakers, researchers, seed companies, consumers, and others directly concerned, will lead to a national program to improve wheat protein levels and flour baking quality. Your support is invited and is needed. We believe this will have outstandingly favorable results for all concerned, including the miller, the baker, and the farmer.

The consumer will benefit from bakery foods with higher levels of protein nutrition, better flavor, mouthfeel, and softness. Internationally, American wheat can once again be recognized as a quality wheat to be first choice, instead of second best.

We interpret your response to this perceived need of the baking industry as an opportunity for the wheat breeders and the wheat farmer to reestablish the dominant position of American wheat in both the domestic and international marketing arenas.

The position of bakery foods in the American diet will also be strengthened, and the consumer can ultimately benefit from increased incentives to incorporate larger amounts of cereal foods in the diet. Current nutritional recommendations are favorable to increased consumption of cereal foods. Our assignment is to make these foods more palatable and more nutritious, at lower cost, so the consumer finds them more attractive.

TABLE 8

IF AVERAGE BREAD CONSUMPTION
INCREASED BY ONLY
1 SLICE PER DAY

FROM AVERAGE OF 5 TO AVERAGE OF 6 SLICES
PER DAY. 20% INCREASE.

63.8 MILLION BUSHELS OF WHEAT
2.8 BILLION POUNDS OF FLOUR
4.5 BILLION POUNDS OF BREADS AND ROLLS

HISTORICAL PERSPECTIVE

Floyd W. Smith[1]

Kansas and other Great Plains States once had a reputation for producing high protein hard red winter (HRW) wheat. That reputation was established many years ago when most of the cultivated Great Plains soils were still relatively high in organic matter content, and hard winter wheat yields averaged less than 15 bushels per acre (bu/A) in a given year.

HRW wheat with relatively high protein content could be produced under such circumstances by simply mining fossil supplies of organic matter in our soils. This organic matter contained substantial nitrogen that could be mineralized into available forms with favorable tillage operations and warm moist climatic conditions.

The virgin soils of the Great Plains region, which subsequently became the main winter wheat producing soils of the United States, were mainly of three great soils groups--Prairie, Chernozem, and Chestnut. These groups averaged about 16,000 pounds per acre (lb/A) of nitrogen in the same depth of profile.

Considering that a good crop of HRW wheat of 50 years ago typically removed less than 35 lb/A of nitrogen, most growers believed that the soil's nitrogen supplying power was adequate for many years of good production. In many respects this is true, but other factors, largely unknown 50 years go, have occasioned generally low levels of protein in wheat grain currently produced. These factors have had substantial effect.

(1) Using improved varieties and hybrids has accelerated removal of nitrogen from the soil. During the 1920's, wheat yields in Kansas averaged about 13 bu/A; during the 1970's, average yield has been about 32 bu/A, or some 2.5 times as high.

Probably more significant is the Kansas average of 37 bu/A in 1973 and knowing that with a repeat of 1973 growing conditions, an average yield of 44 bu/A is possible. Nitrogen demands are not going to decrease.

(2) Extended use of the internal combustion engine firmly entrenched the alternate crop-fallow system as an effective means of producing satisfactory hard winter wheat yields over about half the Great Plains area. This practice also has accelerated the loss of fossil organic matter and its contained nitrogen from the dryland soils.

---

[1]Director, Kansas Agricultural Experiment Station, Kansas State University, Manhattan 66506.

(3) The agricultural chemicals industries, particularly the synthetic nitrogen fixation process, have done much to encourage higher wheat yields but, in too many cases, have done almost nothing to promote higher protein of the grain produced.

(4) Hard winter wheat producers seldom have received premium prices for higher protein wheat. Because of this, more emphasis has been placed on quantity of production than on quality of product. Mostly plant breeders have responded directly to this philosophy and produced wheat with greater and greater yield potential.

Maintaining soil organic matter and its associated nitrogen is not an easy task. Under natural conditions, before the native grasslands, Prairies and Chernozems, were plowed, an equilibrium existed between formation of organic matter by vegetation and its decomposition by micro-organisms. The balance was determined primarily by climatic conditions. Thus the nitrogen content re-remained fairly constant. But cultivation disturbed this balance, and a resultant lowering of nitrogen content occurred. In wheat-growing areas, the loss in nitrogen content amounted to 20 to 40 percent of the original amount after only 20 to 40 years of cultivation.

The loss was most rapid during the first 20 years, amounting to about 25 percent of the original quantity; about 10 percent during the second 20 years; and about 7 percent during the third 20 years. This suggests the establishment of a new equilibrium in cultivated soils, which would be decidedly below that existing under natural conditions--perhaps only 50 to 60 percent of the original level.

Concern about the general decline in the protein content of hard winter wheat is not new.

(1) During 1930-32, P. L. Gainey, M. C. Sewell, and H. E. Myers did much to bring about an understanding of how nitrogen fertilizer could be used to halt this decline.

Using a rather inferior nitrogen carrier (calcium cyanamide), they demonstrated that liberal nitrogen application would elevate protein content appreciably. Also, they conclusively demonstrated that tall, dark, green spots occurring in grazed wheat fields were the result of cattle urine deposits supplying urea that favorably stimulated wheat yields and protein content.

Unfortunately, little attention was paid to their work at that time. Low wheat prices and complacency on the part of dryland farmers did little to bring about practical application of their findings.

(2) After World War II, nitrogen fertilizer materials became available at more favorable prices and in better physical form (prilled ammonium nitrate).

Under the leadership of Myers, the Kansas Agricultural Experiment Station soon offered practical recommendations pertaining to nitrogen fertilizer application for hard winter wheat.

(3) During the 1960's, dominance of superior varieties such as Bison with its excellent protein quality and Scout wheat with exceptional yield capability caused more attention to be focused on possibility of applying nitrogen fertilizer to increase not only wheat yield but also to raise protein content in hard winter wheat.

(4) The 1970's, with their appreciably higher average yield level of hard winter wheat, intensified concern about the declining protein content. For example, the Kansas wheat protein average of only 11.2 percent in 1975 was the fifth lowest on record dating back to 1948. Similarly, the 1974 crop, with its average of but 11.3 percent, was well below the 1964-73 average of 11.7 percent. More important, five of the eight Kansas counties comprising the northwest Kansas crop reporting district had 11.0 percent or less of protein in 1975. Once this area had been regarded as the best for producing high protein wheat in Kansas.

Extensive fertilizer trials conducted in Kansas for 15 years after World War II provided substantial information relative to the effects of applying nitrogen to Kansas wheat. These may be summarized along the following lines:

<u>Fate of nitrogen fertilizer applied to wheat</u>--May be used to increase yield of grain, straw, or both; may be converted into extra protein in grain, straw, or both; or may remain in the soil as part of the total nitrogen reserve.

Effects can be illustrated somewhat along these lines: Small applications of nitrogen of about 25 lb/A are not likely to increase protein content of Kansas wheat. Sometimes, when large yield increases result from small nitrogen applications, a lower grain protein content may result than when fertilizer is not applied. This kind of effect is most likely to occur if (1) the relatively small amount of nitrogen is applied in combination with phosphatic fertilizer, or (2) if the nitrogen is applied relatively early in growing season.

Intermediate amounts of nitrogen, for example 50 lb/A, almost always give near maximum yield increases and usually a slight increase in protein content of grain.

Large nitrogen applications (100 lb/A) almost always increase protein content of HRW wheat.

<u>Some observations with nitrogen fertilizer</u>--Between 1948 and 1953, 50 lb of nitrogen furnished at seeding, along with phosphate and potash, did not often increase protein content of wheat.

One hundred lb, also applied at seeding, gave an average increase of somewhat over 1 percent of protein. This was fairly consistent from year to year.

As early as 1950, research tests demonstrated that foliar sprays of urea can have marked effect on protein content of wheat.

(1) Spraying 50 lb of urea nitrogen right at flowering time raised protein by more than 4 percent. Just applying 10 lb raised it nearly 1 percent, while applying 30 lb raised it 2.5 percent.

(2) Foliar applications made 7 weeks before flowering (April 1) had little effect on protein but did raise yield substantially.

(3) Yield stimulation from urea sprayed at flowering time was slight.

How do we determine if our wheat is actually low in protein?

(1) Consider the yellow berry situation. If it is 40 percent or higher, it most certainly is low in protein--probably 10.5 percent or less.

(2) Have a protein determination made. If protein is only 10 percent or even less, such wheat was sufficiently nitrogen-deficient, and yield increases of 10 to 15 bu/A could have been had if the field had the potential for a base yield of at least 30 bu/A.

(3) If protein is between 10 and 11 percent, there is a high probability that good yield responses--8 to 12 bu/A--could have been obtained.

Furthermore, prospects are good that heavy applications of nitrogen (75 to 100 bu/A) should have been quite profitable. Consider these northwest Kansas results in 1963:

	Rate of Nitrogen Applied		
County	0	50 lb/A	100 lb/A
Decatur	21 bu/A, 11.2 percent protein	30 bu/A, 12.9 percent protein	32 bu/A, 14.2 percent protein
Rawlins	26 bu/A, 11.0 percent protein	31 bu/A, 13 percent protein	33 bu/A, 14.5 percent protein

For the average of trials conducted in Decatur and Rawlins Counties, wheat yield was increased 7 bu/A by topdressing with 50 lb of nitrogen and by 9 bu/A for topdressing with 100 lb. Furthermore, protein went up nearly 2 percent by applying 50 lb of nitrogen and about 3 percent by applying 100 lb.

In the case of individual trials in Decatur and Rawling Counties, where protein was very low, for example, less than 10 percent, applying 100 lb of nitrogen raised protein by 4 percent.

Some will ask whether or not variety has an influence on protein quality and quantity in Kansas wheat. We can summarize our knowledge along these lines:

Several of today's widely used varieties have wheat protein quality that is superior to that in the average of varieties: Eagle undoubtedly has the best quality among today's varieties; Centurk is superior in quality to most.

Some varieties definitely accumulate more protein from a given amount of available soil, fertilizer nitrogen, or both, than is true with standard varieties.

(1) Eagle can provide about 1 percent greater protein content than its parent variety Scout. Furthermore, it has superior quality. Therefore, it should be given much greater emphasis on the Kansas scene.

(2) Lancota offers about 1 percent higher protein under a given set of Kansas circumstances than does a variety of the Scout or Triumph types. Furthermore, it has quality approaching that of Eagle. It should be given special attention in northern portions of Kansas.

(3) Centurk, combining excellent protein quality and tremendous yield capability, should be subject to special nitrogen fertilizer studies to determine how it can be best produced. Seed quality, seeding rate, and time and rate of nitrogen application should be given special consideration.

THE FUTURE

Future varieties would seem to be even better prospects than today's best. I believe that (1) already commercial high protein lines offer as much as 2 to 2.5 percent higher protein content in grain. These undoubtedly could have appreciable impact in blending of wheat before milling; (2) our firm goal and expectation is that some of our Agricultural Experiment Station lines may provide 2.0 to 2.5 percent superiority compared to Scout. These should be suited to general production in the Great Plains.

PROTEIN IN HARD RED WINTER WHEAT: AN OVERVIEW

Virgil A. Johnson[1]

A low protein problem exists in the hard red winter (HRW) wheat region. To suggest otherwise would reflect lack of awareness of the trend that has been underway since the mid 1960's. How serious is the problem? Is it region-wide or is it confined mainly to certain parts of the region? What are the root causes for the problem? Unless we can correctly identify these, effective strategy to deal with the problem will be difficult to develop.

Much already has been said and written about the situation and the culprits who permitted it to happen. The accusing finger has been pointed at the U.S. Department of Agriculture for its presumed short-sighted philosophy of wheat improvement and marketing. The wheat breeders have come in for their share of criticism for their preoccupation with development of high-yielding varieties. The wheat farmer is criticized for his desire to grow high-yielding varieties even though they may have less protein than is desired by the baking industry. He is criticized for using less N-fertilizer than that required to assure desired levels of protein in the grain he produces. The milling and baking industries are criticized for unwillingness to pay for additional protein. Wheat handlers in turn are faulted for not passing along to the producers protein premiums when they occur.

These points can be argued endlessly. To do so here would accomplish little. I propose, therefore, to examine with you those facets of the protein problem about which there is factual information upon which we can make valid judgements. The panel of which I am a part is composed of wheat breeders. Since our expertise is primarily in the genetics and breeding area, we can best address those questions that are concerned with wheat breeding. Let's examine a few erroneous assumptions or propositions in light of actual situations:

Proposition 1. Wheat breeders in the hard winter wheat region failed to recognize the low protein problem sufficiently early to deal with it effectively.

Active programs of protein improvement through breeding have been underway in Nebraska and Kansas for more than 20 years (*1, 6*). More recently, most of the other states in the region and private seed companies have initiated research to improve protein content. The Nebraska Agricultural Experiment Station and the Science and Education Administration, Agricultural Research,

---

[1]Research leader, Wheat Genetics, Breeding, and Pathology, Science and Education Administration, U.S. Department of Agriculture, University of Nebraska, East Campus, Lincoln 68583.

U.S. Department of Agriculture (USDA) developed the high protein variety 'Lancota,' which was jointly released by Nebraska, South Dakota, Kansas, and Texas in 1975. Seed Research Associates in Kansas developed Plainsman IV and V, which possess genetic capability for elevated grain protein. Limited acreage of these privately developed varieties is being produced in Kansas under contract with a commercial mill. High protein hard winter wheat germplasm has been developed and distributed by the Nebraska and South Dakota Experiment Stations (*4*, *7*). My own continuing concern over the trend toward lower protein in hard red winter wheat is a matter of record (*1*, *2*, *3*, *5*) and need not be restated here.

Proposition 2. USDA used taxpayers' money to fund research for higher-yielding wheats and in the process began to downplay the importance of high protein to good baking quality. It abandoned the search for high protein.

USDA has strongly supported wheat protein research at the University of Nebraska since 1955. It continues to provide substantial funding for this work. The U.S. Department of State, through its Agency for International Development, has provided major financial support for the Nebraska wheat protein research since 1966, and it continues to support the work. USDA maintains the Regional Wheat Quality Laboratory at Manhattan, Kans. The laboratory has cooperated closely with the Kansas State University high protein wheat breeding effort. It does thousands of protein analyses on breeding lines submitted by wheat breeders from HRW wheat producing states.

Proposition 3. High yielding HRW wheat varieties will be low in grain protein content.

The negative relationship between yield and protein does indeed occur in the hard winter wheat region frequently enough to induce some observers to accept it as a general and unbreakable relationship. Accumulated regional nursery data do not support this proposition. Among wheat varieties with equal genetic potential for protein, grown on soil in which nitrogen availability is limited, the higher-yielding varieties can be expected to produce grain with lower protein content. It is a case of dilution of the available nitrogen in more bushels of grain per acre. Given conditions of ample nitrogen availability, the magnitude of the negative yield-protein effect is reduced and, in some situations, disappears altogether. High-yielding varieties, grown in southeastern Nebraska where soil fertility tends to be high because of generous use of N-fertilizer, almost always produce grain with adequate protein content, whereas in western Nebraska, these same varieties with yields comparable to those of southeastern Nebraska frequently will have undesirably low protein grain. The varieties have not changed--only the production conditions and soil fertility levels. This largely accounts for the low protein problem in the hard winter wheat region being confined in most years to the central and southern high plains wheat production areas where precipitation is low and unpredictable and use of nitrogen fertilizer has been limited.

Proposition 4. New productive HRW wheat varieties, beginning with 'Scout,' possess lower genetic potential for grain protein than the old, less productive varieties.

For most new productive varieties grown in the HRW wheat region, demonstrating lower genetic potential is not possible for grain protein. The fact that such varieties may frequently be lower in protein than less productive varieties does not address the question of genetic potential. As breeders, we must be concerned primarily with attributes of the wheat plant that can be fixed. Only the inherited traits are fixable.

Data contained in tables 1, 2, and 3 provide solid evidence that genetic potential for protein has not been lost in Scout wheat, which for several years dominated the hard winter wheat acreage of the United States. In the Nebraska Intrastate Nursery the yield of Scout 66 ranged from 15.4 bu/A higher to 10.8 bu/A lower than that of Cheyenne in 1973 and 1974 (table 1). Its protein content was equal to or higher than that of Cheyenne in 9 of 10 trials. During the same period Scout 66 was much more productive than 'Turkey' in all of nine Nebraska Field Plot trials (table 2). Its protein content was higher than that of Turkey in three of the trials. Scout also was more productive than Kharkof in all of five Nebraska trials of the Southern Regional Performance Nursery (SRPN) (table 3). The protein content of its grain was essentially equal to or higher than that of Kharkof in three of the trials.

Contrary to losing protein potential, increased genetic potential for protein can be demonstrated for some of the newer varieties being grown in the region. The mean yield and protein of Scout and Centurk grown at SRPN sites for 9 years are compared with the Kharkof control in table 4. The average yield advantage of Scout over Kharkof of nearly 10 bu/A was associated with an 0.8 percent depression of grain protein. The protein depression in Scout as shown in tables 1, 2, and 3 can be attributed entirely to protein dilution associated with its 10 bu/A higher productivity. Centurk, during the same 9 years, was 3.1 bu/A higher yielding than Scout, but its grain protein content remained equal to that of Scout on the average. This suggests a higher genetic potential for protein in Centurk than in Scout. The Kansas variety 'Sage' was higher yielding on the average than Scout and Centurk during 5 years of testing in the SRPN, but its grain protein content was higher than either Scout or Centurk (table 5). Lancota is compared with these varieties over 3 years of SRPN testing in table 6. Although its mean yield was only slightly lower than that of Centurk and higher than Scout, it exhibited a mean protein advantage of 1 percentage point over these varieties and 0.5 percentage point over Sage.

<u>Proposition 5</u>. The continuing decline in the protein content of hard winter wheats in the southern and central high plains can be overcome by breeding high protein varieties.

The problem can be alleviated but not solved by the development and use of high protein varieties alone. The performance of Lancota in the SRPN is a case in point (fig. 1). Although its yield ranged from 10 to 16 bu/A higher than the Kharkof control from 1972 to 1974, the protein content of its grain remained equal to or higher than that of Kharkof. In contrast, other productive experimental varieties, as a group, exhibited protein significantly lower than that of Kharkof. If soil fertility of the SRPN test sites were permitted to decline to the apparent level of many commercial fields in the high plains area, the protein content of both the nonproductive Kharkof and Lancota also could be expected to decline to an unacceptable level.

TABLE 1.--Comparative grain yield and protein content of Scout 66 and Cheyenne in the Nebraska Intrastate Nursery in 1973 and 1974

Test site	Year	Relative peformance of Scout 66	Scout 66 Yield (bu/A) Actual	Scout 66 Yield (bu/A) Relative to Cheyenne	Scout 66 Protein (percent)[1] Actual	Scout 66 Protein (percent)[1] Relative to Cheyenne
North Platte	1974	more productive than Cheyenne	53.5	+ 15.4	12.5	+ 0.8
Clay Center	1974	"	45.2	+ 14.2	12.0	+ 1.3
Sidney	1973	"	38.7	+ 10.6	14.3	- 1.9
Mead	1974	"	50.2	+ 9.5	11.7	+ 1.2
Clay Center	1973	"	43.1	+ 3.0	12.3	+ 0.4
North Platte	1973	similar to Cheyenne	41.2	- 0.5	13.7	- 0.1
Mead	1973	less productive than Cheyenne	46.0	- 3.7	14.4	+ 0.3
Sidney	1974	"	42.2	- 3.8	14.0	+ 2.5
Alliance	1973	"	31.9	- 9.4	14.2	+ 0.1
Alliance	1974	"	27.5	- 10.8	14.8	+ 5.5

[1] 14 percent moisture.

TABLE 2.--Comparative grain yield and protein content of Scout 66 and Turkey in the Nebraska field plot trials in 1973 and 1974

Test site	Year	Relative performance of Scout 66	Scout 66 Yield (bu/A) Actual	Scout 66 Yield (bu/A) Relative to Turkey	Scout 66 Protien (percent)[1] Actual	Scout 66 Protien (percent)[1] Relative to Turkey
Mead	1974	more productive than Turkey	66.7	+ 23.2	12.5	+ 0.3
Clay Center	1974	"	45.4	+ 22.9	12.6	+ 0.9
North Platte	1973	"	37.5	+ 13.6	12.3	- 1.3
Mead	1973	"	53.0	+ 12.9	13.4	- 0.4
Clay Center	1973	"	42.6	+ 9.1	10.9	- 0.5
Alliance	1973	"	29.9	+ 8.3	10.8	- 1.2
Sidney	1974	"	41.5	+ 6.2	11.0	+ 1.0
Sidney	1973	"	32.0	+ 6.2	10.5	- 1.7
North Platte	1974	"	45.0	+ 5.0	12.0	- 0.4

[1] 14 percent moisture.

TABLE 3.--Comparative grain yield and protein content of Scout 66 and Kharkof at Nebraska sites of the Southern Regional Performance Nursery in 1973 and 1974

Test site	Year	Relative performance of Scout 66	Scout 66 Yield (bu/A) Actual	Scout 66 Yield (bu/A) Relative to Kharkof	Scout 66 Protein (percent)[1] Actual	Scout 66 Protein (percent)[1] Relative to Kharkof
North Platte	1974	more productive than Kharkof	62.5	+ 28.4	13.8	- 0.2
Sidney	1974	"	50.1	+ 9.6	12.6	+ 0.1
North Platte	1973	"	42.3	+ 7.1	13.8	- 0.5
Sidney	1973	"	33.9	+ 5.7	14.5	- 1.2
Alliance	1974	"	35.5	+ 1.8	12.5	+ 0.9
Clay Center	1973	similar to Kharkof	44.7	- 0.4	11.8	- 0.4

[1] 14 percent moisture.

TABLE 4.--Grain yield and protein of Scout and Centurk compared with the Kharkof control during 9 years of evaluation in the Southern Regional Performance Nursery (1968-1977)

Variety	Year of release	Yield (bu/A)	Protein[1] (percent)	Protein (lb/A)
Kharkof	control	35.5	13.9	296
Scout	1963	45.2	13.1	355
Centurk	1971	48.3	13.1	380

[1] 14 percent moisture.

TABLE 5.--Grain yield and protein of Scout, Centurk, and Sage compared with the Kharkof control during 5 years of evaluation in the Southern Regional Performance Nursery (1972-1977)

Variety	Year of release	Yield (bu/A)	Protein[1] (percent)	Protein (lb/A)
Kharkof	control	35.9	14.1	304
Scout	1963	45.8	13.3	365
Centurk	1971	48.8	13.2	387
Sage	1973	49.4	13.6	403

[1] 14 percent moisture.

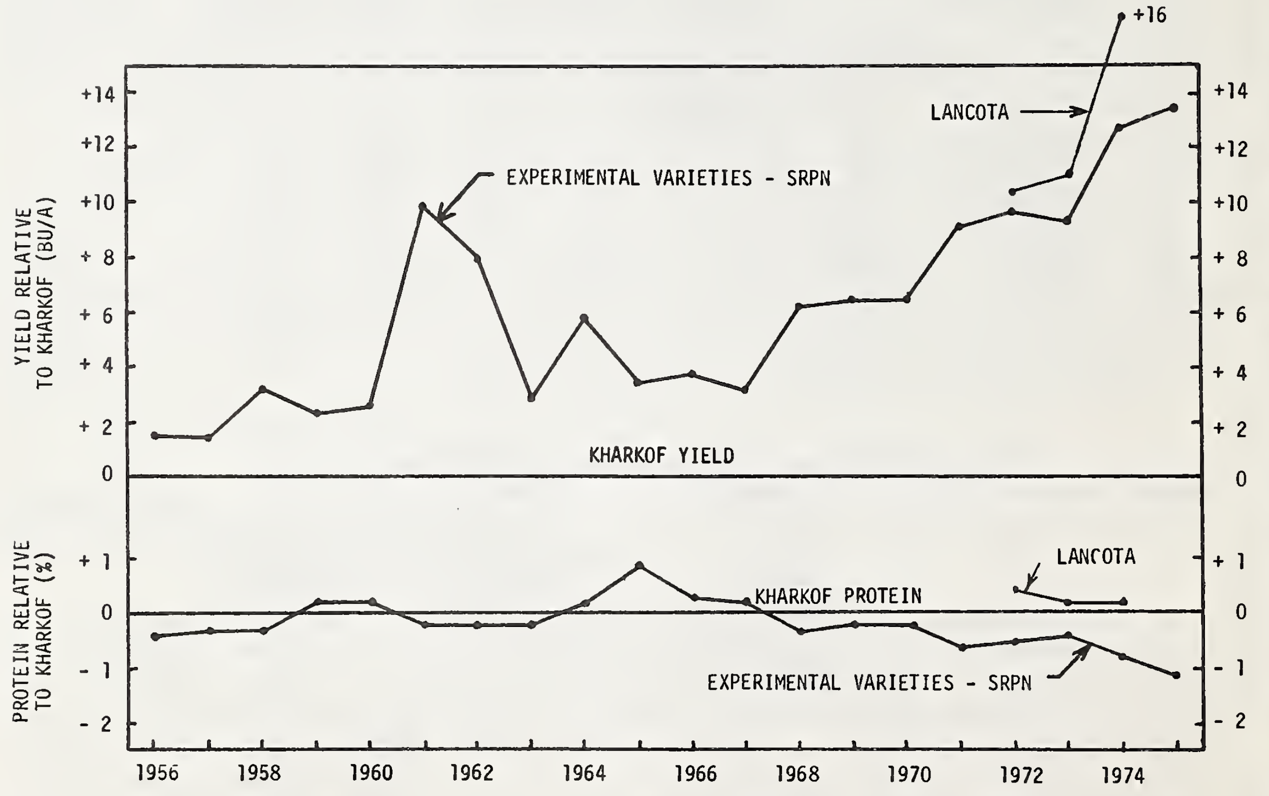


Figure 1.--Annual mean yields and protein contents of experimental varieties grown in the Southern Regional Performance Nursery in relation to the Kharkof check variety, 1956-1977.

Further evidence can be found in table 7. CI14016, a relative of Lancota with Atlas 66 genes for high protein, produced grain with only 12.5 percent protein when grown at low-fertility Nebraska sites with no applied nitrogen. The 'Lancer' variety with the same yield had an unacceptable 10.8 percent protein on the unfertilized plots. Application of nitrogen in 20-lb increments up to 120 lb/A permitted the high protein potential of CI14016 to be more fully expressed. Each 20-lb increment resulted in an approximate 0.4 to 0.9 percentage point increase in the grain protein content of both CI14016 and the Lancer varieties. Application of 40 lbs of nitrogen, an amount commonly used by wheat farmers in central and western Nebraska, raised the protein content of Lancer to only 11.8 percent — not high enough for breadmaking purposes. CI14016, on the other hand, produced grain with 14 percent protein with application of 40 lbs of nitrogen. Clearly, the use by farmers of productive varieties with genetic potential for elevated grain protein in combination with N-fertilizer applications to maintain a moderately high level of soil fertility would be the most viable solution to the low protein problem.

Proposition 6. Further improvement in the genetic potential for high grain protein is possible in HRW wheat.

Numerous genes appear to exist for elevated protein in cultivated wheat and its relatives. Some combinations of these genes have produced protein levels substantially higher than that of Lancota in productive experimental lines in Nebraska and Arizona tests (*4*). Such gene combinations eventually will be transferred to HRW wheats that possess high yield and other agronomic traits necessary for them to be competitive in commercial production. The excellent milling and baking properties of high protein varieties like Lancota and Plainsman V indicate that high protein potential is compatible with required processing quality.

Outlook. Several HRW wheat varieties with genetic potential for elevated protein already have been developed and are being grown commercially in the region. Further breeding progress toward productive, high quality, high protein new varieties is possible. Genes that affect level of protein in wheat grain are widespread and can be used to improve the level of protein in HRW wheat, provided breeding programs possess the laboratory capability to routinely select for the protein genes in early breeding generations.

The continuing problem of low protein wheat in the central and southern high plains reflects mainly a problem of depressed soil fertility rather than use of low protein varieties. Higher rates of nitrogen fertilizer application in the problem areas could effectively raise the average level of wheat protein. The level of N-fertilizer required to achieve more protein usually is higher than the level from which a positive yield response can be anticipated. Therefore, the marketing system must provide economic incentives to encourage producers to apply nitrogen at sufficiently high levels to assure higher protein in their wheat. At present, these incentives do not exist. I believe that a permanent solution to the problem will require the use of productive varieties with high protein potential in combination with improved farm fertilizer practices.

TABLE 6.--Grain yield and protein of Scout, Centurk, Sage and Lancota during 3 years of evaluation in the Southern Regional Performance Nursery (1972-1974)

Variety	Year of release	Yield (bu/A)	Protein[1] (percent)	Protein (lb/A)
Kharkof	control	34.3	13.8	284
Scout	1963	44.3	13.0	346
Centurk	1971	47.3	13.0	369
Sage	1973	48.1	13.5	390
Lancota	1974	46.5	14.0	391

[1] 14 percent moisture.

TABLE 7.--Average yield and protein responses of C114016 and Lancer wheat varieties to nitrogen fertilizer at low fertility Nebraska test sites in 1969 and 1970

Nitrogen applied (lb/A)	Grain yield (bu/A)		Protein content (percent)	
	Lancer	C114016	Lancer	C114016
0	38	38	10.8	12.5
20	44	41	11.2	13.3
40	47	44	11.8	14.0
60	46	45	12.6	14.9
80	46	45	13.2	15.4
100	46	45	13.6	15.8
120	45	46	14.0	16.3
$LSD_{.05}$	1.7	1.7	0.3	0.3

References

(1) Johnson, V. A. 1976. Opportunity to improve the nutritional value of wheat through breeding. 9th National Conference on Wheat Utilization Research Proceedings, Seattle, Wash. ARS-NC-40:54-60.

(2) Johnson, V. A. 1978. Protein in hard red winter wheat. Bakers Digest L11 No. 2:22-28.

(3) Johnson, V. A., A. F. Dreier, and P. H. Grabouski. 1973. Yield and protein responses to nitrogen fertilizer of two winter wheat varieties differing in inherent protein content of their grain. Agronomy Journal 65:259-263.

(4) Johnson, V. A., J. W. Schmidt, and P. J. Mattern. 1971. Registration of high protein wheat germplasm. Crop Science 11:141-142.

(5) Johnson, V. A., J. W. Schmidt, P. J. Mattern, and A. Haunold. 1963. Agronomic and quality characteristics of high protein F_2-derived families from a soft red winter-hard red winter wheat cross. Crop Science 3:7-10.

(6) Miezan, K., E. G. Heyne, and K. F. Finney. 1977. Genetic and environmental effects on the grain protein content in wheat. Crop Science 17:591-593.

(7) Wells, D. G., and C. R. Cowley. 1976. Registration of SD69103, Hand, and Flex winter wheat germplasm. Crop Science 16:888.

BREEDING FOR HIGH PROTEIN CONTENT IN KANSAS ADAPTED HARD WINTER WHEATS

Elmer G. Heyne[1]

We have been interested in wheat protein in Kansas for many years. The work since its initiation has been in cooperation with the U.S. Department of Agriculture (USDA), Hard Wheat Quality Laboratory. Finney (*1*) was interested in different sources of nitrogen compounds on wheat protein for basic research. Foliar application of nitrogen (urea) was made on Pawnee in 1949 on the North Agronomy Farm at Manhattan, and the protein content was raised from 9.5 to 16.0 percent. This changed the appearance of the grain from yellow berry to dark hard. Since that time we have used late application of nitrogen (late boot stage) to increase the protein content of our breeding material that we analyze for quality. In 1953-1954, we made our first crosses with Atlas 50 and Atlas 66 but did not continue the study because of lack of funds. A grant from the Kansas Wheat Commission in 1962-63 made it possible to pursue the work. This was discontinued in 1975. In 1977 some funds were made available for infrared analyses in the Grain Science Department, Kansas State University, and continued in 1978. We made 5,000 protein analyses in 1978, about half of what we would like to. Mixogram analyses and experimental baking are still being done in the USDA laboratory.

Longtime accumulation of data in the Hard Wheat Quality Laboratory indicated that cultivars differ genetically in protein content. Comanche was the first cultivar detected, and at the same time it was noted that Wichita was lower than average. Other cultivars observed that have above average protein content are Sturdy, Eagle, Trison, and Parker 76. Middleton and others (*4*) reported Atlas 50 and Atlas 66 had higher protein content. Routine tests of breeding lines in the Hard Wheat Quality Laboratory isolated several South Dakota lines as being higher in protein. Seed Research, Incorporated, reported that Plainsman V had high protein content. These increases in protein content occurred by chance, that is, there was no specific attempt to breed higher protein wheats. These cultivars with higher protein content potential have given the wheat breeder encouragement that the same thing can be done in a directed manner.

We are using the following sources of higher protein content in our breeding program: Atlas 50; Atlas 66; S.D. lines 69103, 69105, 69107; Argentine wheats (Magnif, and so forth); Nap Hal; Nap Hal/Atlas 66 (Nebraska lines); and Plainsman V. These have been crossed to a number of adapted Kansas cultivars.

Our breeding populations have been small because of the expense of analyses. Material from our first cycle of breeding demonstrated that protein content could be increased in hard wheats adapted to Kansas. This is summarized in table 1. Data from 20 sites in replicated trials show we have trans-

---

[1]Professor of agronomy, Kansas State University, Manhattan, Kans. 66506.

Table 1.--Grain yield, protein content, and protein yield of two Kaw/Atlas selections compared with Kaw at 10 locations in Kansas in 1973 and 1974

	Grain yield compared with Kaw	Protein content	Protein yield compared with Kaw
	Percent	Percent	Percent
Kaw/Atlas 50	98	12.6	105
Kaw, control	100	11.8	100
Kaw/Atlas 66	108	13.3	122

ferred some of the high protein potential of the Atlas soft wheats to hard wheats. If the protein premium would be consistent and high enough, a cultivar would not have to yield more grain than the standard cultivars to be successful. Although we developed breeding lines better than Kaw, they are not equal to our present day cultivars in agronomic performance. A high-protein cultivar to be grown by the farmer must yield as much as other cultivars available to him. Past information has shown a premium for protein in hard wheat is not always available.

Our major problem in evaluating our wheat lines for protein content is the great amount of variation caused by environment. It appears that the variance for protein content is greater than that for yield.

We have limited information with different methods of growing our breeding material to obtain the best estimate of protein content. By trial and error, our best results occur when we seed a standard cultivar every fifth row and grow the breeding lines at two locations. We obtain only one protein analysis on the line, as a composite sample is prepared by bulking equal amounts of grain from two (or more) locations. Lines exceeding the nearest checks by 1 percent or more protein are reseeded. We found that the standards often vary as much as 3 percent in protein content in a distance of 30 feet or less.

At present we are combining different sources of higher protein content into one genotype, for example, the Atlas, South Dakota, and Plainsman V sources into one breeding line. All the recent crosses we have made are directed towards short-stature wheats with resistance to soil-borne mosaic virus. Our latest thrust is to transfer higher protein content to semidwarf hard white wheats.

Some genetic and statistical studies have been made on the breeding material. Lofgren and others (*2*) showed that protein content has a reasonable amount of heritability, indicating it is practical to breed for higher protein wheats. Although the data reported suggest only several major factors are involved, it has not seemed to be so in actual breeding operations. This probably is caused by the great effect environment has on the protein content of wheat. Our statistical studies (Miezan and others, *3*) showed that significant differences in protein content due to genetic effects are as important as environmental effects, so genetic increase in protein content can be expected.

We have had difficulty in obtaining good milling and baking properties in some of the breeding lines. This was especially so with the Atlas 66 crosses. We now have a number of high-protein lines that have good quality characteristics. Other undesirable associations of high protein have been with low yield, poor-quality grain, tall straw, and late maturity. Many of these obstacles have been overcome except the association with lower yields but not necessarily lower protein production per acre.

Most of the sources of higher protein content come from Argentine wheats or *Agropyron*-derived cultivars. For this reason, we have attempted to induce added variation for protein content by use of mutagens. We treated Parker, Shawnee, Kaw, and a selection from Concho/2*Triumph, KS644 with EMS. We grew about 16,000 M1 plants and selected only those that appeared to be normal, vigorous looking plants. Our LD was about 50 percent. We did have a number of weak and undesirable plants. At present, we have only 24 breeding lines left. All but one have about 0.5 to 1.0 percent higher protein content. One line from the cultivar KS644 has significantly lower protein content than the original. We expect to isolate from these mutant lines some desirable agronomic types with higher protein content after the 1979 season. The Parker lines have been agronomically poor; the Kaw and Shawnee lines average or below; but several promising lines are present in KS644 material. The higher-protein content isolates have not been used in crosses to determine whether we have different and significant changes. Differences shown among the lines in mixogram characteristics apparently were caused by EMS treatment.

We have used a number of adapted cultivars as parents, and we obtain the greatest number of high protein lines when Parker 76 is the adapted hard wheat parent. Triumph contributed low protein potential.

Significant evidence is available to show that protein content of hard wheats can be raised above the average protein content of our currently grown cultivars and also equal them in agronomic traits.

REFERENCES

(*1*) Finney, K. F., J. W. Meyer, F. W. Smith, and H. C. Fryer. 1957. Effect of foliar spraying of Pawnee wheat with urea solutions on yield, protein content, and protein quality. Agronomy Journal 49:341-347.

(*2*) Lofgren, J. R., K. F. Finney, E. G. Heyne, L. C. Bolte, R. C. Hoseney, and M. D. Shogren. 1968. Heritability estimates of protein content and certain agronomic properties in bread wheats (*Triticum aestivum* L.). Crop Science 8:563-567.

(*3*) Miezan, Kouame, E. G. Heyne, and K. F. Finney. 1977. Genetic and environmental effects on the grain protein content in wheat. Crop Science 17:591-593.

(*4*) Middleton, G. K., C. E. Bode, and B. B. Bayles. 1954. A comparison of the quantity and quality of protein in certain varieties of soft wheat. Agronomy Journal 46:500-502.

PROTEIN IN HARD RED SPRING WHEAT

Richard C. Frohberg[1]

A North Dakota wheat grower produces a crop of 'Waldron' hard red spring (HRS) wheat. This wheat genotype interacts with an environment on a North Dakota wheat farm to produce a phenotype with agronomic and quality characteristics. Genotype, environment, and phenotype are three words to describe the complex and inter-related task of achieving the needs and desires of the HRS wheat producer, processor, and consumer.

We measure the phenotype to evaluate the effects of the genotype and environment. Varietal differences, fertilizer treatments, and different milling techniques are measured by some final product or characteristic such as the phenotype. Protein in HRS wheat is such a characteristic.

Regional wheat protein

Wheat protein data developed by the Doty Laboratories (1) for Montana, North Dakota, Minnesota, and South Dakota are summarized in figure 1 (2). The trend lines are computed by the method of least squares. The average wheat protein content was above 14.5 percent for Montana and North Dakota, and South Dakota. Minnesota had an average of 13.8 percent for the 17-year period. The trend line increases for North and South Dakota and decreases for Montana. Although it increases for Minnesota, the average protein in Minnesota has been below the statistical trend line in 5 of the past 6 years. These trend lines are an indication of some varietal or genotypic influences, especially in the Montana and Minnesota crops. Increased nitrogen fertilization may have a confounding effect, though excessive nitrogen fertilization is not the solution for attaining acceptable protein levels (3).

The quantity and quality of the wheat protein is indicated by the farinograph absorption (figure 2). The average farinograph absorption for 1961 to 1977 exceeds 63 percent, except in Minnesota. The trend in North Dakota and in South Dakota is toward increased absorption; in Montana and Minnesota, it is on the decrease.

Varietal improvement efforts

Genetic manipulation appears to be the best approach to maintain a certain protein content or obtain higher protein levels along with yield improvements. During the past 10 to 12 years, a number of high yielding varieties have been released in the HRS wheat region. The data shown in table 1 are indicative of the quality deficiencies of four of these varieties for several selected

[1] Professor, Department of Agronomy, North Dakota State University, Fargo 58105.

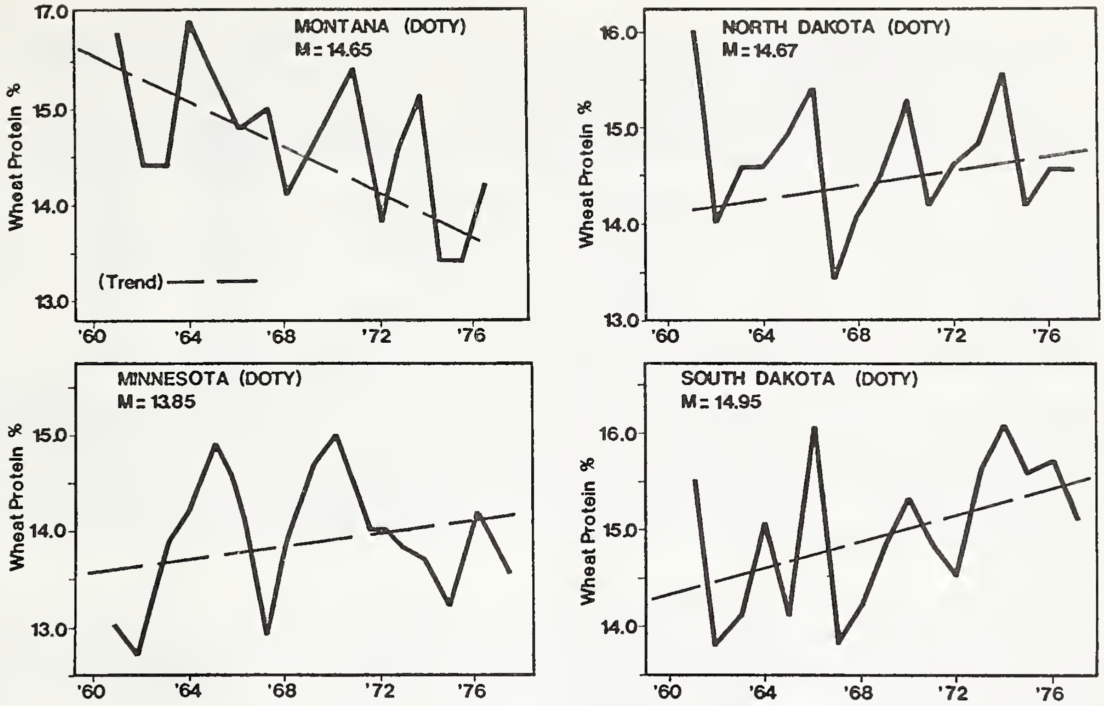


Figure 1.--Wheat protein content, trends and average (M) for Montana, North Dakota, South Dakota, and Minnesota hard red spring wheat crops, 1960-77.

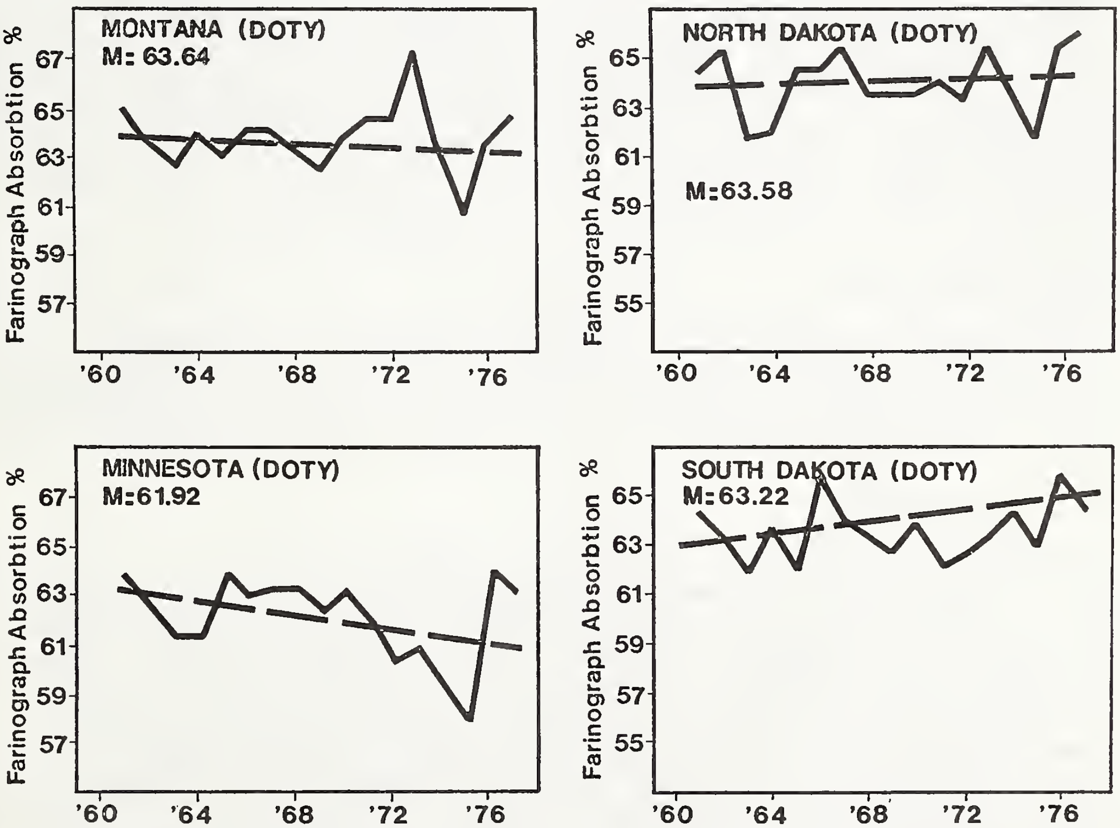


Figure 2.--Farinograph absorption, trends, and average (M) for Montana, North Dakota, South Dakota, and Minnesota hard red spring wheat crops, 1960-77.

Table 1.--Quality characteristics of selected HRS wheat varieties grown in North Dakota trials

Variety	Wheat protein	Adsorption	Loaf volume	Farinogram peak time
	Percent	Percent	cc	min
Chris	15.8	63.6	921	7.0
Waldron	16.0	63.5	924	7.5
Variety "A"	15.1	59.5	804	18.9
Variety "B"	14.3	59.8	854	8.6
Variety "C"	15.5	63.5	859	11.4
Variety "D"	15.4	63.3	910	7.7

Table 2.--Wheat protein content of selected HRS wheat varieties grown in North Dakota trials

Variety	1977	1976-77
	Percent	Percent
Chris	15.2	16.3
Waldron	15.3	16.5
Era	13.4	14.6
Olaf	14.7	15.8
Lew	-	15.8
Eureka	15.3	-
Angus	14.6	-
Coteau	15.8	-

characteristics. When compared to 'Chris' and Waldron standards, varieties A and B are inferior for wheat protein, absorption, and loaf volume. Variety A has very long dough mixing properties. More recently such varieties as C and D have been released. The quality data for C and D indicate an improvement over A and B but are not equal to Chris and Waldron (table 1).

New varieties are the products of wheat breeding efforts. Wheat protein comparisons for some recent HRS releases are shown in table 2. 'Eureka' and 'Coteau' are equal to or better than Waldron. 'Angus', a semidwarf, is an improvement over 'Era'. Though comparable data are not shown, 'Lew', a sawfly resistant wheat, is superior to 'Fortuna'.

New experimental lines are evaluated constantly in a breeding program. Five advanced experimentals from programs in the HRS wheat region are compared with Chris, Waldron, and Era (table 3). Although absorptions are satisfactory except for one line, these quality comparisons indicate acceptable loaf volumes and mixing times. Grain proteins are below Waldron. Protein content is the one consistent fault. If grain yield improvements continue, then I am not optimistic about genetically increasing the protein level at these higher yield potentials unless more research effort is forthcoming.

HRS breeding objectives

A wheat breeding team has many agronomic and quality objectives to consider (table 4). Protein is just one of these, though it is inter-related with several other quality characteristics. A discussion about protein in HRS wheat becomes purely academic if the stem rust fungus destroys the crop.

High protein germplasm

The success of an attempt to genetically improve spring wheat for protein is dependent primarily on the presence and type of variability in wheat populations. If some hereditary differences are present, then genetic progress should be possible by selection; however, if all variability is due to the influence of macro- or micro-environmental factors, then selection would be futile. Differences caused by the interaction of genetic factors with the environment may be more fully used if we are willing to breed wheat varieties for certain management systems, that is, specific adaptation. If genetic variability for the desired protein levels does not exist in natural populations of wheat or it's related species, then induced mutations and artificial transfer of genetic material are alternative sources of variation.

Table 3.--Quality of characteristics of experimental HRS wheat lines and three commercial varieties

Variety or line		Wheat protein	Absorption	Loaf volume	Mixing time
		Percent	Percent	cc	Min
Chris		15.9	65.2	968	2.7
Waldron		16.1	66.8	977	3.7
Era		13.7	62.8	910	3.6
Experimental	1	14.9	63.7	943	2.9
	2	14.8	65.7	960	3.4
	3	14.5	64.7	960	3.5
	4	15.1	64.8	993	3.3
	5	15.2	66.8	1012	4.1

Table 4.--Hard red spring wheat breeding objectives

Major wheat characteristics	
Agronomic	Quality
Grain yield	Protein
Test weight	Wheat
1000 kernel weight	Flour
Plant height	Flour yield
Maturity	Ash
Lodging resistance	Wheat
Nonshattering	Flour
Disease resistance	Mixing
Stem rust	Time
Leaf rust	Tolerance
Foliage diseases	Dough handling
Insect resistance	Absorption
Wheat stem sawfly	Loaf volume
Cereal leaf beetle	Crumb
	Color
	Grain and texture
	Crust color

At the present time, most spring wheat breeders in the HRS region attempt to exploit genetic variation in segregating populations from the hybridization of selected parents. Thus the procedures used for selection of parents for crossing and the techniques for evaluating the resulting progeny largely determine the success of breeding for protein content. Briefly, in the evaluation process certain criteria need to be established and then, preferably, objective tests applied to eliminate those progeny that fail to meet the standards. The key to the entire breeding process is genetic variability. This concept cannot be over emphasized. Long term and stable research efforts are needed. Areas where intensive basic research is now being conducted will be exploited in the future by sound, broadly based, wheat research programs.

Genotype, environment, phenotype--three concepts to describe wheat from seeding to consumption. As a breeder, I have emphasized the genotype and the phenotype as a final measure. The environment molds the genotype in the final analysis, thus controllable or predictable environmental factors should be and are manipulated. Tillage, fertilization, weed control, transportation, storage, milling techniques, and baking procedures are important links in the chain from the genotype to the phenotype.

References Cited

(1) Spring wheat quality reports. 1962-1977. James W. Doty, director, Doty Laboratories, Inc., Kansas City, Mo.

(2) Gilles, K. A., Frohberg, R. C., Banasik, O. J., and Anderson, D. E. 1978. Perspectives of the wheat breeder, cereal chemist, and economist relative to the flour protein problem. Presented at the American Bakers Association Technical Liaison Committee, U.S. Department of Agriculture, Western Regional Research Center, Albany, Calif.

(3) Sibbitt, L. D., and Bauer, A. 1970. Effect of fertilizer nitrogen rate on the quality of six hard red spring wheats. North Dakota Farm Research, 27:No. 6. p. 9-15.

PROTEIN IN WHEAT IN PRIVATE INDUSTRY--
A Breeding Survey

James A. Wilson[1]

This brief survey of private wheat breeding institutions was designed to help determine the emphasis, progress, outlook, and general philosophy of protein improvement in wheat. Six institutions--Cargill, DeKalb, NAPB, Northrup King, Pioneer, and Seed Associates--participated in the survey. Although there are additional private firms involved in wheat breeding, these six firms represent an adequate sampling for a survey of this type.

The answers given do not represent the official position of the companies, but they do reveal the philosophy of the wheat improvement teams working in those companies. The responses to questions are given on a group basis rather than by individual company. However, the individual company's response is included but not designated.

The questions and responses are given in the following:

1. Are high protein lines frequently utilized in crosses for the development of improved lines for varieties or hybrids?

   Answer

   5 yes
   1 no (no intentional design in crosses for protein)

2. Are protein tests run on breeding lines prior to yield testing?

   Answer

   4 yes (1 extensive, 3 limited)
   2 no

3. Are protein analyses made on lines, hybrids, or both, during the early yield-test stages?

   Answer

   6 yes

[1]Vice president and director of wheat research, DeKalb Hybrid Wheat, Inc., 1831 Woodrow St., Wichita, Kans. 67203.

4. Can genetic improvements be made in protein and yield simultaneously?

   Answer

   6 yes (1 replied new protein genes are needed)

5. In terms of percentage increase, what are your improvement goals for yield and protein?

   Answer

Percent Yield Increase and	+ percent grain protein increase
10	more than current varieties
20	no improvement in protein
20	0.5 to 1
20	2
30	2
30	3.5

   (note: a 2 percent increase in grain protein over a 12 percent base is 16.7 percent improvement)

6. Are State and Federal wheat workers giving proper attention to the breeding of high protein varieties?

   Answer

   5 yes
   1 no

7. Is the bread-baking industry adequately informed of the significant improvements made in the quality and quantity of protein in hard red winter wheats?

   Answer

   3 yes
   3 no

8. Are varieties now available that are genetically capable of producing high protein if fertilized and managed properly?

   Answer

   6 yes

9. Should more energy be directed towards alerting growers of ways to produce high protein wheat?

Answer

4 yes (1 - only if economic incentives exist)
2 no (1 - growers are adequately informed)

10. Would a marketing system that consistently awarded growers a premium for producing high protein wheat alleviate the "protein problem" of processors?

Answer

5 yes
1 no (need variability in protein levels)

A strong majority of the wheat breeding companies have indicated an emphasis toward developing higher protein wheats. In viewing the progress that has been achieved, indications show that Federal, State, and private wheat breeders have made genetically high protein varieties available to farmers. The outlook for future protein improvement consistent with improvements in yield is strongly optimistic in the majority's view. Most of the breeders surveyed feel that industries interested in high protein wheat should increase their efforts in encouraging growers in ways to produce high protein wheat. The concept is strongly supported that consistent price incentives for the growers would markedly increase the supply of high protein wheat.

WHEAT BREEDING

Kenneth A. Gilles[1]

INTRODUCTION

I am pleased to participate and to discuss "The Breeders' View" of this Wheat Protein Conference. Moreover, I must compliment Dr. Lee Briggle for his leadership in bringing together four eminent plant breeders to represent the Federal, State, and private plant breeding programs in the United States. As a cereal chemist turned administrator, I will try to interject my personal perspective in this discussion and to plan the role of a provocateur.

The Dilemma

"Something has been happening to the baking quality of flour over the course of the last 10 or 12 years. Protein levels have been declining, ash levels are increasing, mixing requirements are higher, and tolerance and uniformity are on the decline" (*1*). These types of comments have appeared to present one side of the current flour protein dilemma; contrary views have been stated also (*2*).

No Easy Answer

This conference is mute testimony to the fact that there is no easy answer to the dilemma.

BREEDING, PRODUCTION, AND PROCESSING TENDENCIES

Because of the size of the United States, many types of bread wheats are produced under a number of environmental conditions. Consequently, the plant breeder has the opportunity to facilitate selection and production of bread wheats having diverse quality and growth characteristics. Because of this diversity, some general comments seem appropriate.

Certainly, with available technology, a baker can establish chemical and physical specifications for flour suitable in the baking process.

Certainly, with available technology, the milling industry can employ competitive procedures to bid for the opportunity to supply the baking industry's needs.

Certainly, with available technology, the grain merchandizing industry can identify, locate, and provide the desired raw material for the milling processors.

---

[1] Vice president for agriculture, North Dakota State University, Fargo 58102.

Certainly, using available technology, the wheat producers can plant, husband, and harvest wheats having desirable characteristics.

I have repeated the words "available technology" because I think we, as members of the wheat industry of the United States, have the "tools", the "available technology", to do virtually whatever needs to be done to improve and strengthen this industry.

HOW DOES A DISCUSSANT PROCEED?

Having said that, how does a discussant proceed?, I have made a few assumptions with which I hope you agree:

Plant breeding programs appear to be well founded, with appropriate goals and capable leadership.

Wheat varieties are available that exhibit a broad spectrum of growth and quality potential.

Provided an incentive exists, people involved in producing, marketing, and using wheat and wheat products are capable of responding to the real and perceived needs of the marketing system.

Our discussion today concerns the domestic markets. What are the key questions to more clearly define the dilemma?

Is the issue merely a perceived decline in flour protein?

Is the issue simply the quantity of protein in wheat and flour?

Is the issue more complex?

Is the issue primarily biochemical, economic, environmental, genetic, or technological?

Although I fear falling into the trap of being overly simplistic, permit me, as discussant, to play the role of the devil's advocate. I submit that the answer to the last question is primarily an issue of economics. However, we must recognize that the other issues contribute to the definitions of the total dilemma.

PLANT BREEDERS

Certainly, the Federal, State, and private plant breeders who have preceded me on this facet of the program have each acknowledged that their breeding programs are broadly based, and that protein content and quality are significant factors in their over-all consideration of program planning. Moreover, they have indicated the folly of concentrating on one quality factor to the exclusion of others. From the scientific standpoint, I believe that the private and public breeding programs are progressing on a sound basis for the potential mutual benefit of the wheat industry.

Indeed, the plant breeders, as well as the chemists and bakers, recognize wheat protein as a pecularily significant component of the baking process. However, for a plant breeding program to concentrate solely on protein content without due regard to the total genetic and farm management considerations is folly. Such emphasis may create an academically interesting curiosity--a variety of wheat having little interest to the farmer, grain merchant, miller, or baker.

INCENTIVES

What are the incentives for the breeder, the farmer, and the agribusinessman?

For the breeder, the incentives include scientific achievement and recognition for achieving the goal of releasing new wheat varieties accepted by the farmer and the entire industry. However, the breeder needs help from others in the industry in establishing realistic goals. Perhaps the major benefit of this conference will relate to goal definition.

For the farmer, the incentives are those associated with improved economic impact, higher prices, increased yields, expanded markets, and increased production and harvesting efficiency.

The quality characteristics of test weight, protein content, milling extraction, and baking quality are less attractive; in fact, these quality characteristics may be disincentives if they are accompanied by adverse economic factors such as decreased yield and potentially lower cash income.

The wheat producers recognize that variety improvement research requires cooperative effort of a number of scientific disciplines applying their best techniques with the knowledge that ultimately variety release decisions must be made by reasoned judgment applied in a conciliatory atmosphere. We must bear in mind that individual wheat producers ultimately select the seed to be planted on their farms. Simply releasing a new variety after years of plant breeding and quality testing work is no assurance that the variety will become widely planted or utilized.

For the agribusinessman, the incentives include an assured supply of wheat having desirable quality characteristics at convenient locations and at attractive prices. Favorable government programs and a seller's market are, likewise, desirable.

HOW HAS THE SYSTEM WORKED?

Obviously, no one is completely happy with all aspects of the U.S. wheat research production, marketing, and utilization system. However, let's pause and look at some critical aspects.

Yields--Have wheat yields increased as a result of plant breeding research? Certainly, yields have increased, and new areas have been brought into production. As a result of research and technological advances, an assured supply of quality wheats is available.

Protein--Has protein in commercial wheat declined rapidly as yields have increased? While certain new varieties display greater yield potential than protein content, data from annual wheat quality reports of the Doty Laboratories, Kansas State Board of Agriculture, and North Dakota State University indicate that adequate quantities of quality wheats are available from commercial sources (*2*).

These reports, together with U.S. Department of Agriculture production information, clearly refute Dr. Jackel's concern that adequate quantities of bread wheats are not available to produce "Bakers' Gold," flour having a minimum of 11.5 percent protein content. According to Jackel, the commercial bread baking industry uses the equivalent of 300 million bushels of wheat. This represents about one-sixth of the U.S. wheat production.

Last year approximately 175 million bushels of spring wheat having at least 15 percent protein was produced. Assuming that the wheat mix used for bakers' flour was enriched by the addition of some of the available higher protein wheats, protein content of bakers' flour would be raised to 12.8 percent by using less than one-third of the available higher protein wheats.

Programs--Do government programs influence the production of quality wheats? As government programs impose acreage restrictions, the yield per acre of wheat assumes greater significance. Protein content and quality become less significant, unless the markets reflect higher prices for higher quality.

Prices--If the baking industry's desired quality characteristic is protein content, then current market prices significantly do not reflect this concern. On Friday, October 13, 1978, the Minneapolis market for hard red spring wheat was $3.36, $3.39, and $3.43 for 13, 14, and 15 percent protein, respectively (table 1). The average of the 1978 crop is 14 percent protein.

Table 1.--Hard Red Spring wheat yield and price Minneapolis, Minn., October 13, 1978

	Yield Bu/Acre	Protein	Price	Gross Income Per Acre	Difference
	28	13	$3.36	$ 94.08	$0
	28	14	3.39	94.92	0.64
	28	15	3.43	96.09	1.96
+0.6 bu yield	28.6	13	3.36	96.09	2.01
+5 percent bu yield	29.4	13	3.36	98.74	4.70
+ 10 percent bu yield	30.8	13	3.36	103.49	9.41

Current economic incentive to produce 15 percent protein wheat versus 13 percent is $1.96, equivalent to six-tenths of a bushel of yield.

With only a seven cent price spread between 13 and 15 percent protein, what is the farmers' incentive to produce the higher protein wheat? Assuming an average yield of 28 bu/A, the difference in gross profit is $1.96. This is the equivalent of six-tenths of a bushel per acre. The gross earnings at 13 percent protein are $94.08 and at 15 percent are $96.04. A producer of 13 percent protein wheat yielding 28.6 bu/A would make $96.09. Not much incentive!

If the 13 percent protein wheat had a 10 percent yield advantage, that is, 30.8 bu/A, the gross return would be $103.49, an increased profit of $9.41 per acre or $1,505.60 per quarter section. If the 13 percent protein wheat had a 5 percent yield advantage, that is, 29.4 bu/A, the gross return would be $98.74, an increased profit of $4.70 per acre or $752.40 per quarter.

Given the current facts, if you were a plant breeder, how would you encourage a producer to plant a variety having greater protein content versus a variety having greater yield potential?

Using the 5-year period, 1971-1975, an economic evaluation of yield, quality, and price differences was observed at six North Dakota branch agricultural experiment stations; the conventional varieties, Waldron, Chris, and Justin, produced high protein wheat. The semidwarf varieties, Era, Bounty 208, and WS 1809, produced wheat having lower protein content and higher test weights. During this time, the semidwarf types having higher yield potential were slowly replacing the conventional varieties, which initially dominated production.

Applying the typical systems of protein premiums and discounts used at the Minneapolis market, the semidwarf variety, Era, having low baking quality, ranked number one in gross return per acre in 18 of 28 selected study situations. Olaf, Bounty 208, Ellar, WS 1809, and Waldron typically ranked relatively high. Of the conventional varieties, only Ellar and Waldron consistently fall among the five most profitable varieties at various locations.

For illustration purposes, table 2 summarizes data for eight wheat varieties grown on dryland at the Minot Agricultural Experiment Station in a major spring wheat producing region. Yield, protein, and gross return per acre are highlighted. Waldron, the variety grown on more than 50 percent of the acres in North Dakota during 1971-1975, displayed the highest average protein content, 15 percent; it has good baking quality. It should be a good variety for the farmer, the miller, and the baker! However, the gross return per acre at both the normal premium and high premium level was $147 and $175 per acre, respectively. Era, the variety representing less than 8 percent of the crop, having a mellow baking quality and the lowest protein content, 12 percent, (3 percentage points or 20 percent less protein than Waldron) had the highest potential gross return at both premium levels, $195 and $207 per acre, respectively. For this 5-year period, Era produced a 39 percent greater yield in the field and from 18 to 33 percent greater potential economic return. I believe this inequity results from farmers' genuine efforts to produce a high quality wheat. They have succeeded! The markets, however, do not differentiate adequately because sufficient quantities of high quality wheat are available to minimize the effect of the smaller quantities of low quality wheat.

Table 2.--Hard Red Spring Wheat. Average yield, protein content, and gross return per acre. Minot Station 1971-1975

	Yield	Protein	Gross Return Normal Premium	Gross Return High Premium
Era	53	12.0	$195	$207
Olaf	46	14.3	176	204
Bounty 208	43	13.6	163	182
Fortuna	42	14.1	160	182
Tioga	40	14.8	153	179
Chris	40	14.6	152	178
Waldron	38	15.0	147	175
Ellar	37	14.6	144	169

Currently, producers of Hard Red Spring wheat in North Dakota are not receiving protein and test weight premiums large enough to provide an incentive to continue to produce high quality wheat varieties. If the markets continue this type of economic incentive, the spring wheat producers will expand acreage of those varieties having the greatest yield.

SUMMARY

If the baking industry really desires to maintain flour protein content, at current or increased levels, I believe that goal can be attained. By paying increased premiums for protein content and good quality, and assuring that wheat producers get the premium at their local elevator, I am convinced that adequate quality can be maintained. However, the wheat merchants, millers, and bakers must provide positive economic incentives sufficiently attractive to encourage farmers to plant wheat having desirable quality.

LITERATURE CITED

(*1*) Jackel, S. S. Bakers Digest 50: 6, 24 (1976).

(*2*) Gilles, K. A., and others. Bakers Digest 62: 3, 26 (1978).

DISCUSSION

Virgil Johnson

High protein genes from related species can be incorporated into cultivated species of wheat. I think this is a distinct possibility. An example may be Plainsman V. I am not sure where the protein genes in Plainsman V come from. Are they from Agropyron or from goat grass? If the pedigree is correct for 'Hand' and 'Flex' out of the South Dakota program, the most likely source of the high protein genes probably is Agropyron.

Recently the Israelies have collected a large number of *Triticum dicoccoides*. This is a noncultivated species of *Triticum*. They have found within *T. dicoccoides* a wide range of differences in protein content of the seed. One of the highest was over 30 percent protein, under some conditions, and it also possessed larger seed than most of the other *T. dicoccoides* collections. There is interest now in the possibility of moving this gene, or these genes, into cultivated species. I know that the Israeli group doing this work already made crosses with *T. durum* and also with *T. vulgare*. So in response to your question, yes, there are opportunities to transfer such genes from related species to cultivated wheat.

But a word of caution. When one undertakes a program like that, there are not many shortcuts. A long and difficult breeding problem confronts the breeder for the reasons that have been mentioned earlier--mainly, that when you transfer the gene, you also are likely to carry with it unwanted genes that may affect many of the functional properties of the wheat grain and the agronomic properties of the wheat plant, which must be eliminated. This is a long-time process. There is an opportunity to improve protein content using genes already available in cultivated wheat. Dr. Heyne and others pointed out how difficult this is because of the large environmental effects. However, it seems to me that, if industry is as concerned as it is about this situation, it should be prepared to seek or provide financial support to breeders in the hard red winter wheat region to permit them to build into their programs evaluation of protein content early in the breeding sequence to provide some assurance of identifying and retaining in new wheats the genes that affect protein. I believe that much progress can be made if this is done.

Tom Roberts

I want to add to Dr. Gilles' remarks regarding the current market economic situation relating to hard red winter wheat. He indicated that spring wheat had about a 7 cent protein premium on the Minneapolis market. The Kansas City market, which is primarily based on winter wheat, was an inverse situation, premium for ordinary or low protein, pointing out another problem.

Several mills represented at this conference have too much protein in the hard red winter wheat crop to meet the needs of family flours. As a result, their efforts of trying to find low protein wheat to fill these needs have been exhaustive. There is a premium for food wheat, based on the fact that protein is there, but search for low protein is demanding and calling for a higher price. This is something we must keep in mind. I would say this points out more of the adversity situation. We need a complete field of selection in protein that meets the demands of the entire industry represented here.

Si Jackel

I have heard the word "incentives" for a long time, and I would like someone to tell me how do we apply them. I talked to Secretary Bergland about this, and he said the solution to your problem is just as simple as paying the farmer more money. Well, is it just that simple? How do we go out and give the farmer more money? In Kansas, they say there is no way for the farmer to get rewarded and that the agribusiness system doesn't allow premiums to funnel

down to the farmer. I think that the answers so far aren't enough. I think it is simplistic to judge on cliches and generalities like these. I think that if we want to work on this problem, we must address it and work out procedures and methods that take the whole agribusiness complex into account.

Another point is that I think it was inappropriate for the Department of Agriculture and others to decide that the baker can afford to pay premiums or that he can afford to settle for lower protein levels. It is the baker who has to announce his capabilities in this area, and it is for the rest of the agribusiness committee to determine how these matters can be resolved. Now the bakers have the chance to stand up and say "you want us to pay incentives, then you tell us how to do it." We respect and appreciate incentives. We look for a profit in what we sell, and we understand that the farmer has to make a profit in what he does. But then don't close the door and tell us that in Kansas there is no way to get premiums to the farmer. If that is the answer, then somebody should work out a system to make these things work and not answer us with cliches.

Johnson

This is not a question for the breeder. We are talking about economic incentives, and I think someone else could better address the question.

George Schiller

At the present time, the decided effort on the part of people buying grain for the Southern Great Plains is to reward the farmer directly for premium grain. This has been put into effect and is working, so when someone tells you the farmer is not getting it now, that is not correct. The farmer didn't use to get it. This is something relatively new. There are two reasons why this thing has been delayed. One of them is that we didn't have the capabilities of analyzing a truckload of wheat quickly enough so we could handle it. We had a logistic problem that is being solved. The other problem is that a great deal of people know, if they want better flour, they are going to have to award the guy who produced it. And that is the farmer. As far as I am concerned, this is already underway, and there are high protein wheats available.

Johnson

I think all of these comments are an accurate overview and summary of what the breeders in the Plains area are thinking about--yield and protein in improving wheat. I would like to know from you industry people, as I am sure the rest of the breeders would, what you think of the way we perceive this situation. What are we not doing that we ought to be doing? If you believe we ought to be doing things that we aren't already doing, then I wish you would suggest ways in which we can find the necessary financial support to do these things.

The finger has been pointed at the wheat breeder for allowing the lower protein trend to happen, but I have heard no one comment about the tremendous job the wheat breeders have done to improve quality per unit of protein. If you had today's protein level in your bakeries 20 years ago, you would really have a reason to complain.

WHEAT PROTEINS: WHAT THEY ARE

John E. Bernardin[1]

Although we discussed wheat protein in general terms, as a chemist, I feel we need to look at it a little more closely. Do we just want to increase the protein content of the wheat kernel? Do we need to know where this protein is located within the kernel? Is it functional protein? Is it nutritionally sound?

To orient ourselves, the first figure shows a quarter section of a wheat kernel. You can begin to see some of the structure of the wheat seed. On the right at the top of the figure there is a bit of the seed coat and immediately underneath this is a layer of cells called aleurone cells. This portion of the kernel usually stays with the bran when the kernel is milled into white flour. The tissue in the center of the figure is endosperm tissue, which constitutes the bulk of flour.

Figure 2 shows the same bit of a kernel at slightly higher magnification. Again, the seed coat is at the upper left-hand corner of the figure. The crease of the kernel is down at the lower right-hand corner, and you can begin to see the shape of the endosperm cells. They are rather long, prismatic cells and, when this kernel is milled into flour, these cells are broken open. The contents of the endosperm cells are thus available when the flour is mixed to form a dough. Each cell contains starch, lipid, protein, and the cellular organelles that constituted the living cell as the kernel was developing.

If we breed wheat for high protein, or if we fertilize the plant so the kernels will have a high protein content, will all, or at least most, of

[1]Research chemist, Western Regional Research Center, U.S. Department of Agriculture, Science and Education Administration--Agricultural Research, 800 Buchanan St., Berkeley, Calif. 94710.

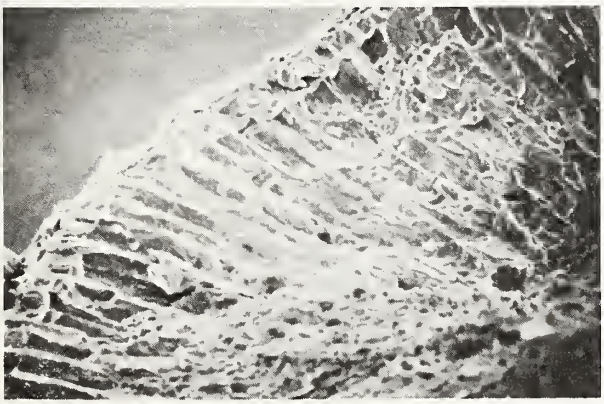


Figure 1.

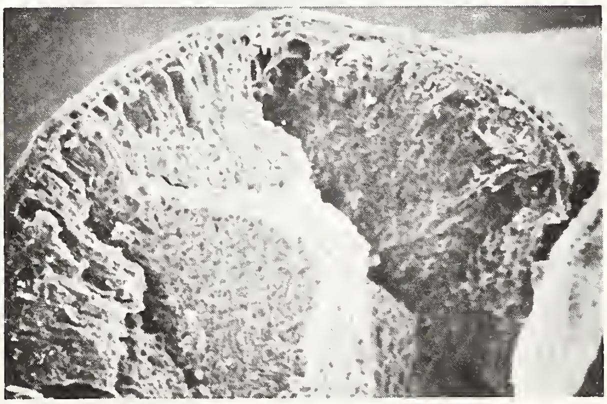


Figure 2.

this protein be in the flour? Several workers have shown by sectioning kernels and staining for protein that protein is distributed within the kernel. The protein content of the endosperm cells increases from the center of the kernel towards the aleurone layer. Well, if we breed for high protein, this increased protein is greatest just under the aleurone layer of cells. This means if we don't extract all the endosperm tissue when milling, most of this increased protein will not be in the flour.

It is also not sufficient just to increase protein in the kernel without considering the type of protein that we are increasing. We must consider the end use of the flour since not all proteins have identical physical properties. These first figures have been mature kernels that were dry. If we look instead at the developing kernel about 15 days after anthesis, or flowering, we can see the initiation of protein deposits within the endosperm tissue.

Figure 3 shows a thin section of such a kernel. The large body in the lower right-hand corner is the nucleus of the developing cell. You can see a large starch granule in the upper right-hand corner and several small circular bodies throughout the tissue. These small bodies are storage protein deposits. Each one of them is bounded by a membrane. This storage protein is to be used by the developing wheat plant when the seed germinates and is degraded into amino acids by enzymes in the seed. These amino acids are used to build the plantlet and roots until the plant can take up nutrients from the soil and begin the photosynthetic process. This storage protein makes up approximately 75 to 80 percent of the protein in the kernel, and this is the protein that appears to be functional for breadmaking.

Figure 3.

General Structural Formula for the α-amino acids found in proteins

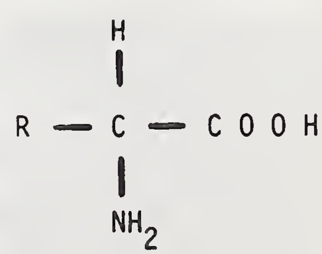


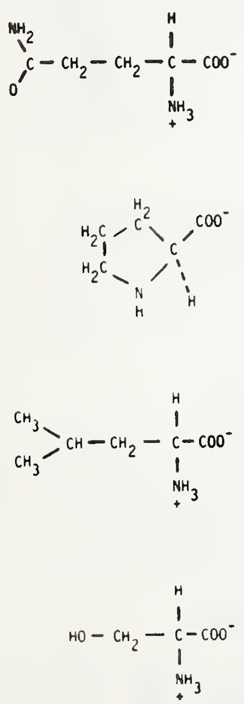
Figure 4.

We have been discussing protein in general terms. I would now like to look a little closer at what a protein is and what it is made of and how it is put together.

Figure 4 shows the general structural formula for the alpha-amino acids that make up all proteins. There are 20 common amino acids, and nearly all of these are found in every protein. They differ in the side chain attached to the alpha carbon atom. The NH_2 group in the lower portion of the figure is the amino group, the carboxyl group is at the right side, and the side chain, R, which distinguishes the amino acids from one another, is at the left. This side chain can be very simple, such as a hydrogen atom resulting in the amino acid glycine, or, it can be a complex structure, such as you would find in tryptophan.

In a protein, these amino acids are strung together in a linear fashion where the OH portion of the carboxyl group and one H from the amino group are eliminated, and a bond is formed between the carbon atom of the carboxyl and the N atom of the amino group. In a typical protein there may be several hundred amino acids. What distinguishes different proteins is the sequence of the amino acids in this linear chain.

Figure 5 shows four of the most common amino acids in the wheat storage proteins. Glutamine is the most abundant amino acid, making up one-third to one-half of all amino acids in a molecule. Proline is next in abundance, followed by leucine and serine. This composition gives the wheat proteins some unique properties and reflects the function of these proteins in the wheat kernel. Glutamine is a good source of nitrogen, and it is an efficient



Glutamine (104)

Proline (39)

Leucine (21)

Serine (14)

Figure 5.

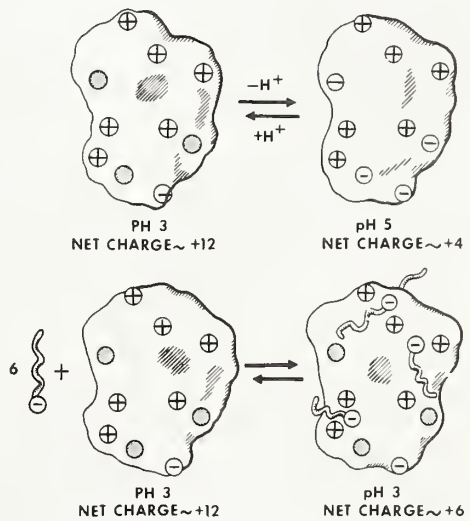


Figure 6.

amino acid for conversion into other amino acids. The number to the right of the amino acid in the figure is the number of this type of amino acid in one of the wheat storage proteins, a gliadin protein.

Such a high proportion of hydrophobic amino acids, glutamine, proline, leucine, and serine, in the wheat storage proteins results in a group of proteins that have large areas of hydrophobic amino acids on their surface. The few charged amino acids that these proteins contain will also be located on the outside of the molecule, where they can interact with water. While the hydrophobic amino acids are buried in the interior, where they are away from water in the aqueous environment of the developing wheat kernel, many will be located on the exterior of the molecules.

Even though glutamine is not a charged amino acid, it does readily form hydrogen bonds with other glutamine residues and with water. The high content of glutamine, both in the exterior of the molecule and on its surface, results in a strong tendency to form hydrogen bonds between different proteins and between the protein and the aqueous solution. This accounts for the tendency of the wheat storage proteins to interact with each other, and it probably is the property that gives them the ability to form the cohesive elastic structure we know as dough.

In figure 6, I schematically show the general structure of the wheat proteins. You can see that I have indicated the charged residues located at various points on the surface of the molecule and that they have a generally globular structure. The slightly shaded areas indicate regions of hydrophobic surface--regions where the nonpolar amino acids are found. By changing the pH of the solution, you can change the net charge on the protein molecule as the various amino acid side chains are ionized or titrated. Most of the wheat storage proteins will have a small positive charge at the pH found in a dough. This means they will have a slight tendency to repel one another. You will also find because of the high content of glutamine and hydrophobic amino acids that they have a strong tendency to associate with one another, and it is a balance between these two types of forces that gives the wheat proteins their rheological properties.

At the bottom of the figure, I have also indicated a reaction that almost certainly occurs within the system of wheat proteins and that also occurs within a dough. The rather squiggly line with a negative charge indicated on it at the left-hand side of the figure is meant to indicate a lipid molecule. There is a large amount of lipid within the wheat endosperm tissue. When these lipids interact with the proteins, they tend to bind to the hydrophobic surface. In binding to the surface, they also bring along that negative charge, which is present at one end of the lipid molecule. This changes the net charge on the protein molecules and allows them to interact even more strongly with one another. This binding of lipid has neutralized some of the positive charge on the molecule and thus decreases the charge-charge repulsion between the proteins.

I have said that these proteins tend to associate strongly with one another, and, in fact, they tend to interact very specifically. Figure 7 shows some of the structures that the wheat proteins form. This is an isolated wheat protein, one of the gliadin molecules, and it forms long linear fibrils. We

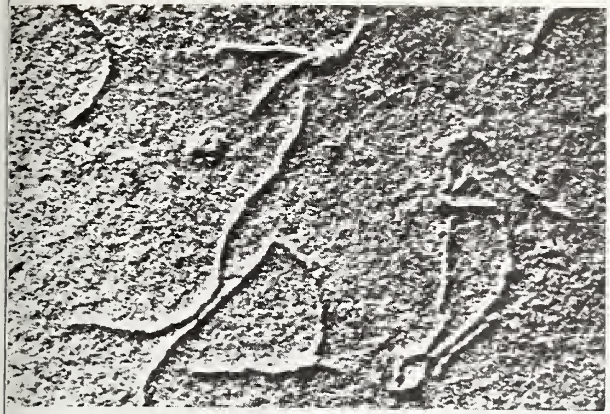


Figure 7.

Figure 8.

cannot see the individual protein molecules that make up these fibrils, but we can show that similar fibrils are formed by many of the wheat storage proteins. We have also found that these fibrils tend to associate specifically with one another.

Figure 8 shows the type of structures observed when a flour particle is wet with a drop of water. Notice that the fibrils tend to align themselves parallel with one another. They form sheet structures and sometimes twist about one another forming rope structures. These are the structural components of dough.

Even though the wheat proteins form siliar structures, they can be distinguished by a number of techniques. Electrophoresis has proved to be a particularly valuable technique and can be used to separate proteins according to their net charge. Figure 9 shows the storage protein electrophoretic patterns for several different varieties of wheat: Omar, Scout, and Justin. I also show a partially purified gliadin protein, which we call A-gliadin. The "A" refers to the ability of this fraction to form fibrillar structures. It is part of the storage protein complex in most hard red winter wheats. This is a technique that we have used to distinguish which proteins were changing as new varieties of wheat have been developed to isolate a fraction of the wheat proteins and then add these back to a flour and observe how this fraction has altered the dough properties or breadmaking properties of the flour. This separation is based on charge.

We also have the ability to separate proteins according to their molecular weight. Figure 9 shows a separation where the proteins have been complexed with a particular detergent, sodium dodecyl-sulfate. When this detergent binds to the protein, it binds in an amount proportional to the molecular weight of the protein. If we then separate these complexed proteins in an electrical field, as we did in the last figure, the mobility is proportional to the charge added by the dodecyl-sulfate, and the separation is therefore based on the molecular weight of the proteins.

When the entire wheat storage protein complex is examined in this manner, as shown in figure 10, we find that most of the proteins have similar molecular weights and only range from 35,000 to 45,000 for 75 percent of the

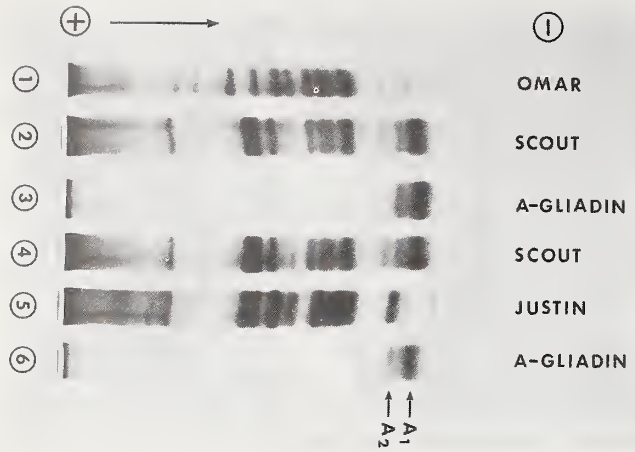


Figure 9.

Figure 10.

proteins. The very top pattern in the figure is the A-gliadin fraction, which has a molecular weight of 35,000 by this technique. The second pattern is the standard protein mixture used to calibrate the experiment, and the third pattern is the gliadin proteins. The fourth pattern is the glutenin fraction, and we see it is composed of two main molecular weight ranges: one group of molecules with molecular weights identical to the gliadin proteins, and a group of proteins with slightly higher molecular weights centered about 45,000. The fifth sample is the wheat storage complex. You can easily see that more than 75 percent of the proteins have molecular weights in the 35,000 to 45,000 range.

I have tried to give you some idea of the similarities of the wheat storage proteins. They have similar molecular weights and they have similar amino acid compositions. However, I have also tried to indicate that there are differences between the proteins. These proteins snow differences in their tendency to aggregate to form fibrils and differences in the tendency of the fibrils to associate with one another. It is the aggregation tendency that seems to be unique to the wheat proteins. Other cereal grains do not have proteins that exhibit this unique aggregation, even though they have proteins with similar amino acid compositions. This means that when we increase the protein content of wheat, we will want to do so in a specific manner. We are going to have to know what types of proteins we are changing and what their contribution will be to the properties of dough.

DISCUSSION

Yeshajahu Pomeranz

Thank you very much for handling such a complex problem of the genetics of proteins in wheat grown under adverse climatic conditions. Let me start with a question about something I have always wanted to ask but didn't know to whom. Any increase in total protein content is almost invariably associated with an increase in storage proteins. This is an increase in functional proteins. At the same time, there is a decrease in nutritional value. Is there anything that can be done about it or is it a problem of asking for a warm frost, which most of us would like to have this time of the year when we think about our backyard garden.

John E. Barnardin

Well, I agree. When you increase the protein content of wheat you generally are increasing the amount of storage protein. Storage protein is somewhat deficient in some of the amino acids having such a large preponderance of glutamine and proline in their sequence. This means that some of the essential amino acids are not increased in an amount proportional to what you would like for good nutritional properties. I think, though, that if you were to increase the specific amino acids that are essential and that are lacking in the wheat storage proteins, you would find that you would be losing many of the functional properties that you wish in those proteins, so I don't know whether there is a solution. By increasing the total amount of protein, you will increase some of the essential amino acids but certainly not in the amount that you would like to.

Pomeranz

It would seem that the answer is compromise rather than miracles.

George E. Inglett

Is there an increase in the glutamine of storage protein with nitrogen fertilization? And how extensively has the protein composition of the wheat kernel been studied with respect to the nitrogen fertilization?

Bernardin

There generally will be an increase in the storage protein, yes, with nitrogen fertilization. If you look at the change in protein composition with increased fertilization, you increase the storage protein predominantly. This would mean an increase in glutamine but, as we indicated earlier, it is not changing the other proteins that are essential for the synthesis of the storage protein. You generally increase just the storage proteins themselves. This would mean that you would be increasing glutamine and proline, as far as the amino acid composition. It increases both the gliadine and glutamine portion, as we normally separate them in roughly proportional amounts to the amount of fertilizer that is added. You ask how extensively has the chemical breakdown applied to the amino acid composition, and how much work exactly has been done in this area of the wheat varieties that have been nitrogen fertilized as opposed to most of the genotypes. As far as I know, all genotypes respond similarly to nitrogen fertilization in that they increase the storage protein, and I don't think there is a change in either the amino acid composition or the protein from variety to variety or different genos. They all seem to respond in a similar manner.

Pomeranz

You mentioned that the glutamine varies between 30 and 50 percent. I wonder whether you get the 50 percent upper level with nitrogen fertilization.

Bernardin

No. When you increase the amount of protein synthesized by applying fertilizer, you keep the same balance between the different types of storage protein. The proteins that are synthesized are specific for the variety of wheat that you are growing. And if you increase one, you increase all of these. So the ratio between the amino acids or between the different types of proteins that are being synthetized stays roughly the same. The amount of glutamine in the protein is coded, for it is in the genetic history of the particular variety. The range from 30 to 50 percent glutamine is a range that you find in the different proteins that I showed separated in the electrophoretic pattern, for example.

If I understand your comment then, what you are doing is drawing a parallel between the Z as storage protein in maize and the gliadine protein in wheat. The discrepancy, I think, arises only in the way we separate and the way we name the different protein fractions in corn or maize compared with wheat. They generally have the same type of proteins. The Z would be similar to the gliadine protein and the glutenin generally similar to the glutelin fraction that you would find in maize.

But it is a rather artificial separation that we make. They generally are all storage proteins. It is just that the separation is a little cleaner in maize than it is in wheat. The gliadine protein is the storage protein. The glutanin protein seems to be more associated with the structural components or the membrane proteins or involved in the protein synthesis structures that you find within the maize. In wheat, the separation is not as clean and, perhaps, the conclusion is that the glutanin proteins are contaminated with storage protein. So it appears to be increasing both classes of proteins in a similar matter when you fertilize them heavily.

Pomeranz

I think that, by and large, in wheat a protein response to nitrogen fertilizer results in an increase of all four major types of protein; however, the increase is proportionately higher in storage protein than in soluble protein. This is correct for wheat, even though not as strong as in maize. It is also correct in barley. In malting barley this has been of concern for many years. When you fertilize barley, you get more protein, mainly storage protein, that creates problems in malting and in brewing.

In wheat, it is not as pronounced as in the other grains, but it is still there. I think one of the advantages of Atlas crosses is that while there, too, an increase takes place, it is slightly less than in normal wheats, which gives a certain nutritional advantage to Atlas crosses. This advantage may be very small but apparently, real. Has the state of knowledge of these proteins reached the point where testing for the different proteins could be of value in wheat selection and breeding programs?

Bernardin

The question is, has our research reached the point where we can, if I understand you correctly, tailor-make a variety of wheat? Can we tell you which proteins need to be increased specifically to control flour or dough properties? That certainly is one of the goals of our research, but we have not reached that point yet.

We can show some rather drastic differences depending upon which class of proteins are added back to a flour or dough makeup. We are just beginning to make some real advances here, I think. Eventually, we hope to be able to tell you "Yes, if you want to increase the mixing time of a flour, or decrease it, you would add a certain class of proteins back." Eventually, our research will allow us to understand the genetic control of these particular proteins so we can say, "If you want to decrease the mixing time, you would make a certain cross or you would add a certain chromosome to the normal complement of wheat chromosomes that you would find in the variety."

WHEAT PROTEINS: WHAT THEY DO

Karl F. Finney[1]

Wheat is too often regarded as merely a starch food crop, but it contains other valuable nutrients, notably proteins, lipids, minerals, and vitamins. The prominence of wheat is attributed not only to its nutritive value but also to its unique proteins. Unlike any other plant-derived food, wheat contains gluten protein, which enables a leavened dough to rise by forming a structure of minute cells that retain carbon dioxide produced during fermentation.

To show what proteins do necessitates relating their quality and quantity to important functional (breadmaking) properties. These include (slide 1) flour protein content, mixing requirement and tolerance, dough handling characteristics, water and oxidation requirements, loaf volume potential, and bread crumb grain.

Total Proteins and Physical Dough Properties

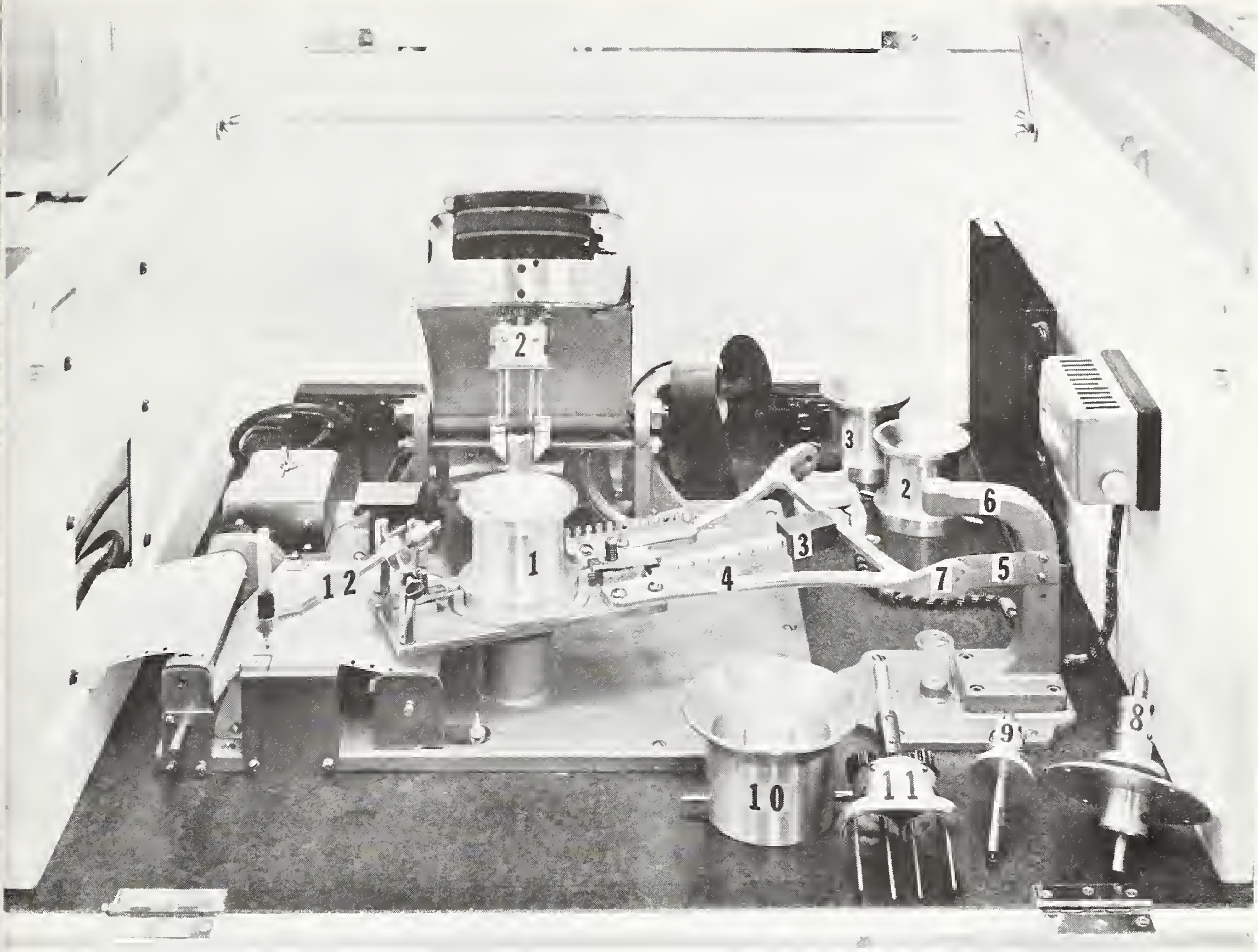
The effect of quality and quantity of proteins on mixing properties can best be objectively determined by mixograms obtained on a mixograph. The mixograph (slide 2) is composed of two pair of planetary pins that revolve about three pins in the bowl that contains 10 g of flour and optimum water. As mixing proceeds, water is absorbed and the dough is progressively developed so that the resistance to the planetary pins passing through the dough increases and is recorded on paper moving about three-fourths in/min. Typical mixograms are illustrated in slide 3. The distance from one major arc to the next is 1 min and from a major to a minor arc one-half min. Other things being equal, the peak or point of minimum mobility is the mixing requirement for optimum bread production.

Slide 1.--Functional (breadmaking) properties of bread flours.

FLOUR PROTEIN
MIX REQUIREMENT AND TOLERANCE
DOUGH HANDLING
WATER REQUIREMENT
OXIDATION REQUIREMENT
LOAF VOLUME POTENTIAL
CRUMB GRAIN AND COLOR

---

[1]Research leader, Grain Quality and End Use Properties Research Unit, Grain Marketing Research Laboratory, U.S. Department of Agriculture, Science and Education Administration, Agricultural Research, 1515 College Ave., Manhattan, Kans. 66502.

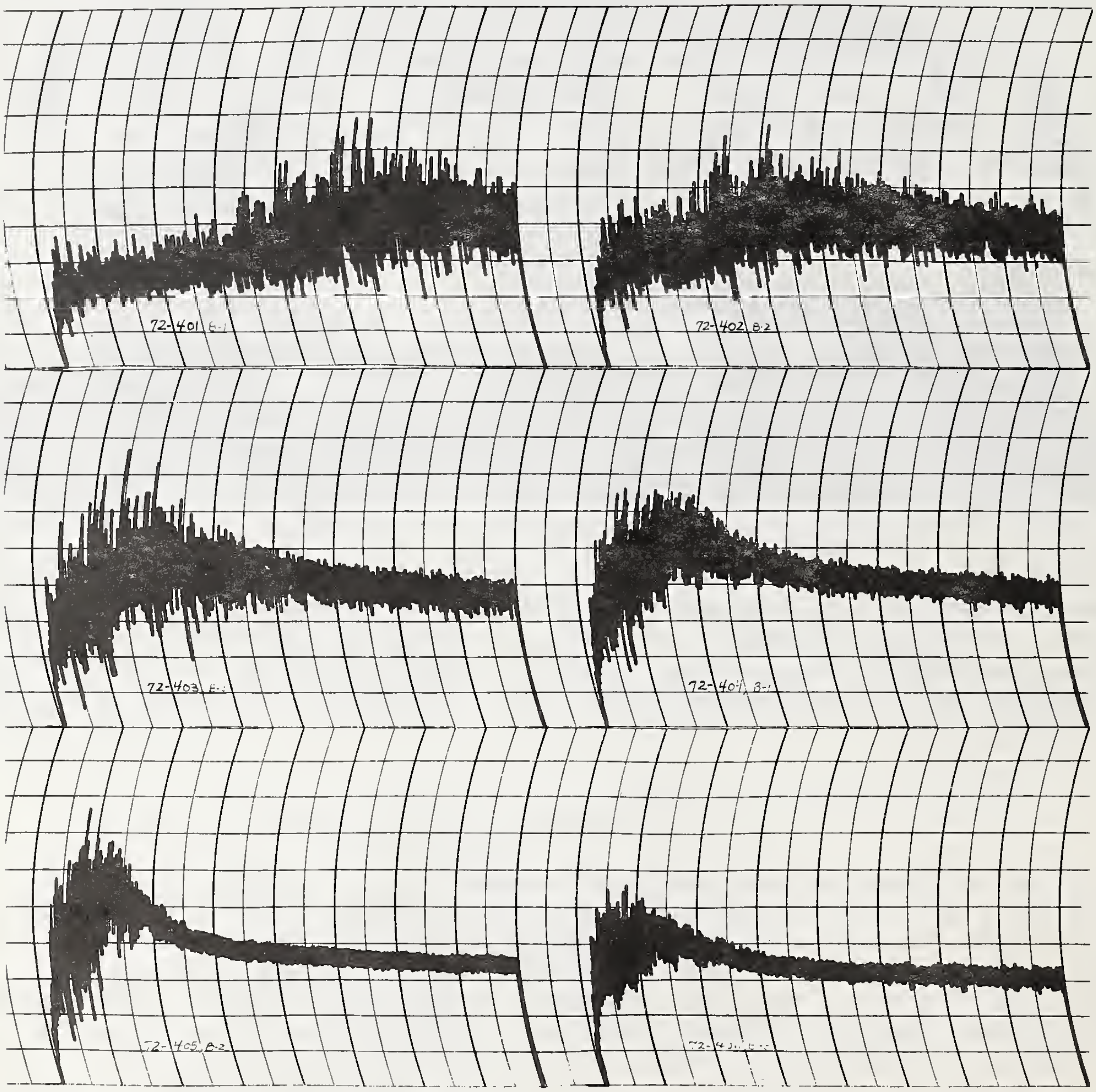


Slide 2.--Mixograph for recording mixing properties of 10-g samples of wheat flours. Bowl (1) is in operating position, directly below the raised mixing head (2) and its two planetaries, each with two pins that revolve in a predetermined pattern about three stationary pins in the bowl. The pen arm (12) with screw-in pen and black drawing ink exerts about 6 g of pressure on the recording paper.

A medium to medium-long mixing requirement, corresponding to the peak of the top right mixogram, generally is most desirable. Thereafter, from left to right and top to bottom, mixing properties vary from questionable to unsatisfactory. Slope and width after the peak and stability of mixogram height on each side of the peak are indices of mixing tolerance. All flours used in slide 3 contained about 12 percent protein, so that the variations in mixing properties were functions of protein quality.

At 7.5 percent protein (slide 4), the mixing time of Pawnee was about $4\frac{1}{2}$ min; at 9.9 percent protein, mixing time decreased to $2\frac{7}{8}$ min; at 11.6 percent protein and above, mixing time was $2\frac{1}{8}$ to $2\frac{3}{8}$ min. Previous studies in our laboratory have shown that when protein decreases below about 12 percent,

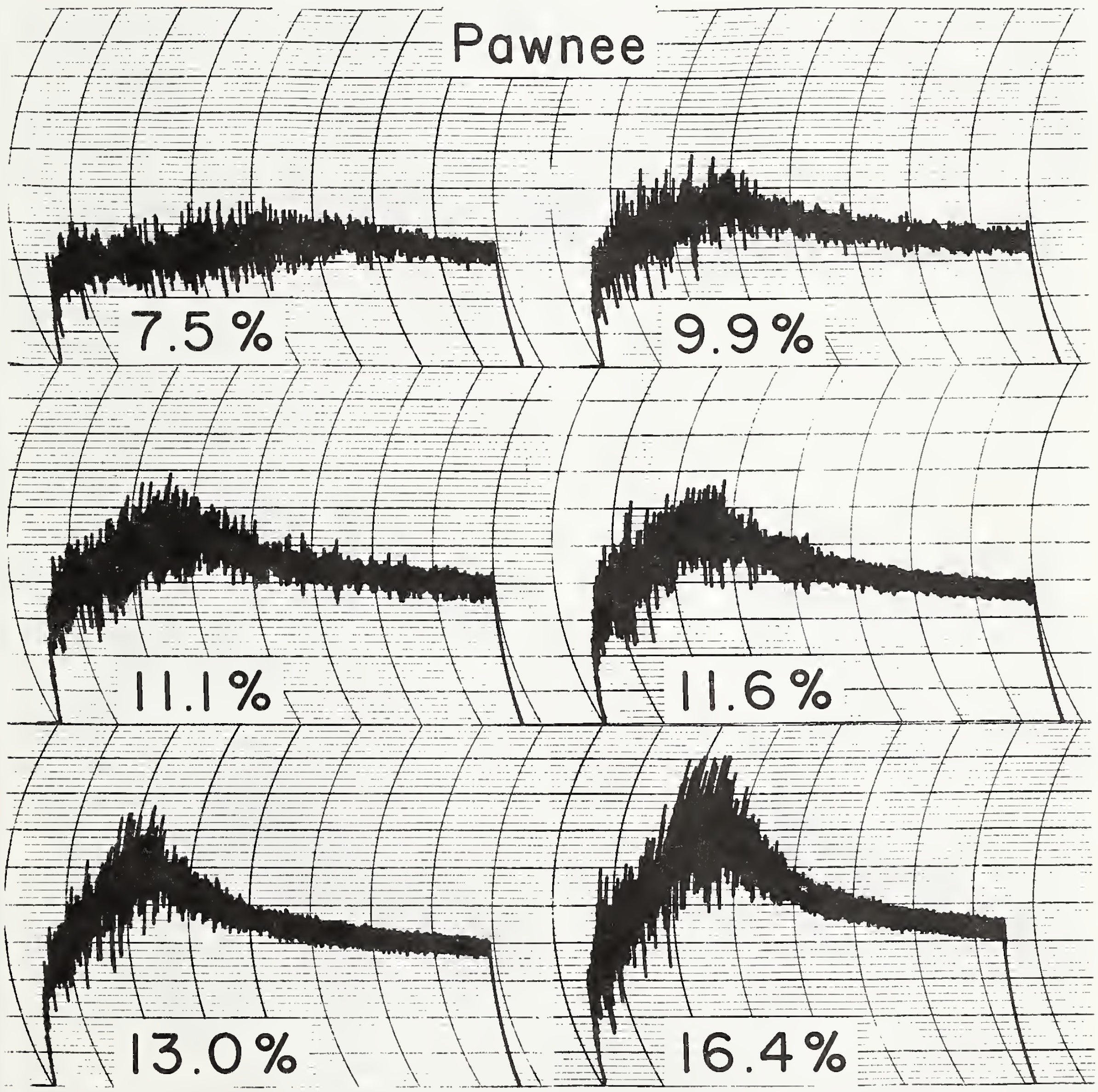
mixing time increases, primarily because the lower the protein below 12 percent, the greater the difficulty in forming a continuous phase of protein. The higher the protein, the higher the mixogram on the paper. Pawnee has a relatively short mixing time and mellow physical dough properties. Quivira/Tenmarq/Marquillo/Oro (slide 5) has medium-strong to strong physical dough properties. At 8 percent protein, mixing time was about 10 min; at 10.4 percent protein, mixing time decreased to about 7 min; at 11.5 percent protein, mixing time decreased to $5\frac{3}{8}$ min; and at 13.1 percent and 16.2 percent protein, mixing times were about $4\frac{5}{8}$ min. Like Pawnee, mixing time greatly increased as protein content decreased below about 12 percent protein. Thus, both the quality and quantity of proteins affect the mixing properties of bread wheat flours.



Slide 3.--Typical mixograms of hard winter wheat flour (10 g) that vary in mixing requirement (time to peak) and mixing tolerance (slope and width after peak, and stability of mixogram height on either side of peak). Major arcs are at 1-min intervals.

Total Proteins and Water Absorption

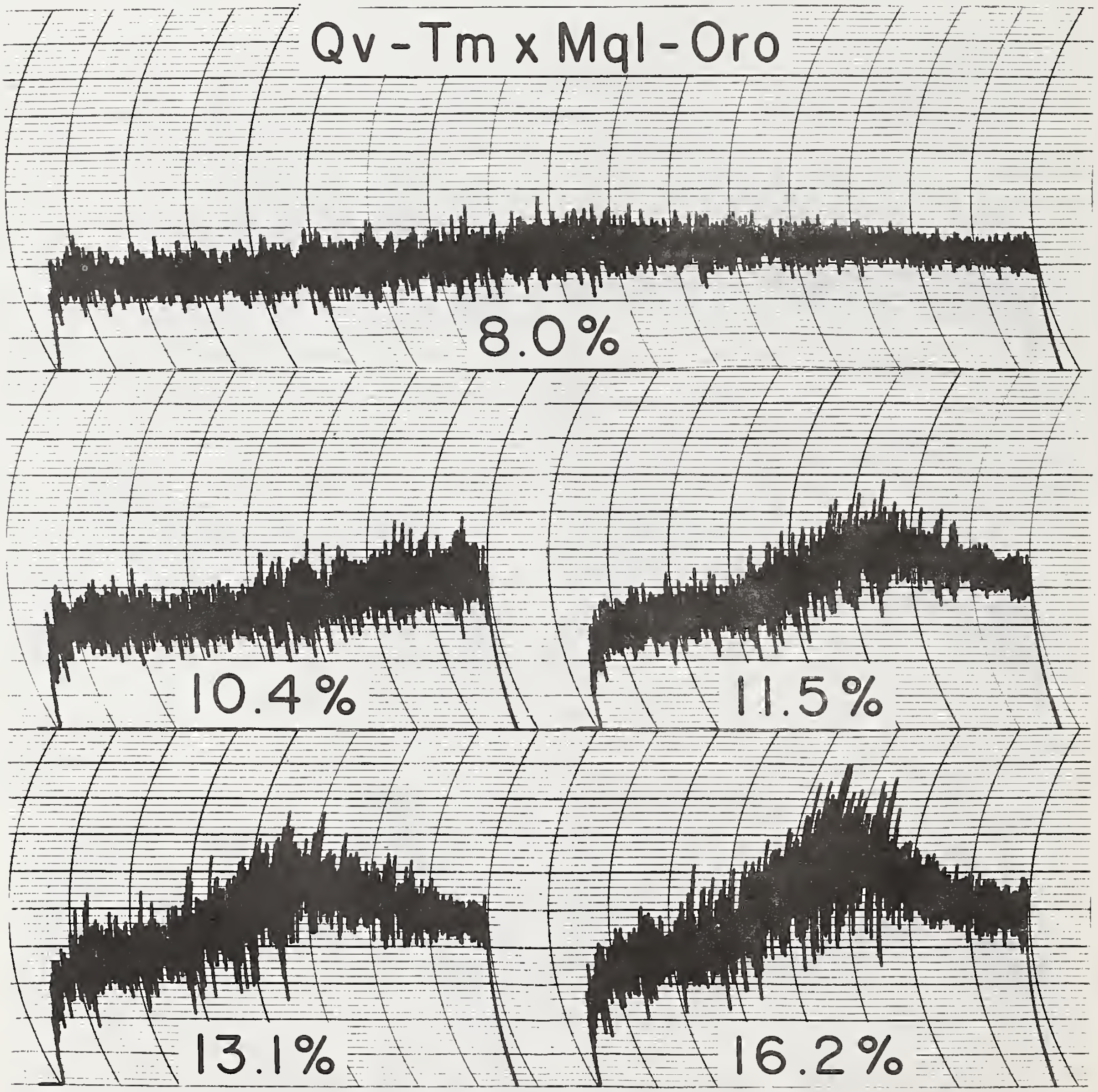
As protein content increases within a variety (slide 6), water absorption increases. Each regession line represents 25 to 100 experimental points. The regression lines form a fan-shaped family of lines that show the quality differences in water absorption at any given protein content. Thus, water absorption is a function of the quantity and quality of wheat flour proteins.



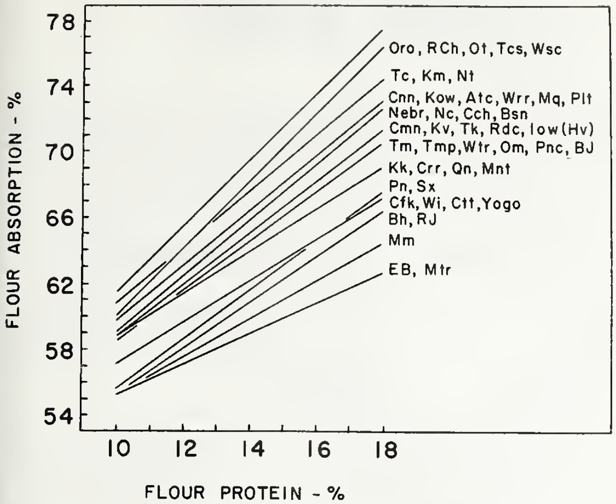
Slide 4.--Effect of flour protein content on mixogram characteristics of Pawnee, a short-mixing hard winter wheat flour.

Total Proteins and Oxidation Requirement

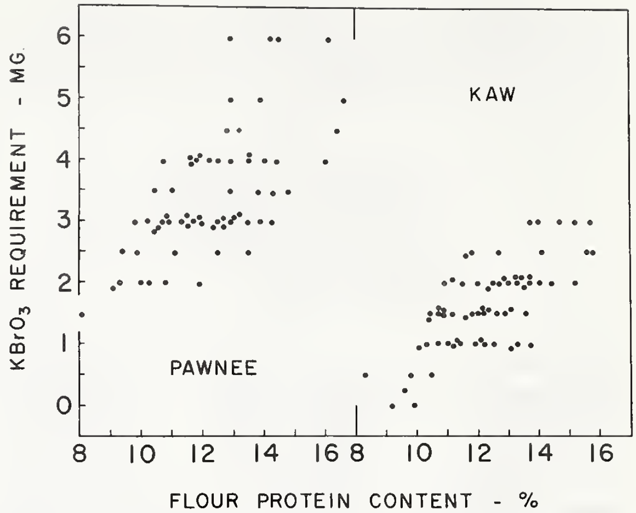
Bromate requirement (slide 7) of Pawnee varied from 1.5 mg per 100-g flour containing 8 percent protein to 6 mg at 16 percent protein (average about 4 mg). Kaw, a medium-strong bread flour, required no bromate at about 8.5 percent protein and 3 mg at 16 percent (average about 1.5 mg). Pawnee, with mellow physical dough properties, required nearly three times as much oxidation as did Kaw. Thus, oxidation requirement of bread wheat flour is a function of both the quantity and quality of proteins.



Slide 5.--Effect of flour protein content on mixogram characteristics of Quivira/Tenmarq/Marquillo/Oro, a medium-long-mixing hard winter wheat flour.



Slide 6.--Flour absorption versus protein content regression lines for 42 hard winter and 3 hard spring wheat varieties. Each variety regression line represents many samples harvested throughout the Great Plains during several crop years. Occasionally, experimental progenies fall on the top line or below the bottom line.

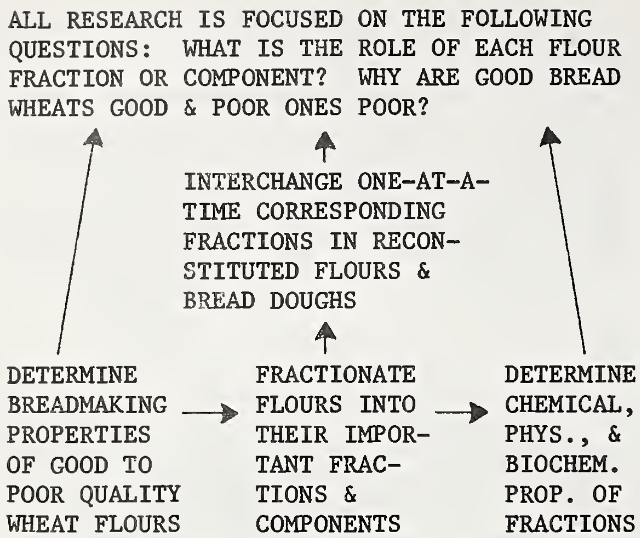


Slide 7.-- Relation between oxidation ($KBrO_3$) required and flour protein content of Pawnee and Kaw, short- and medium-long-mixing hard winter wheat flours.

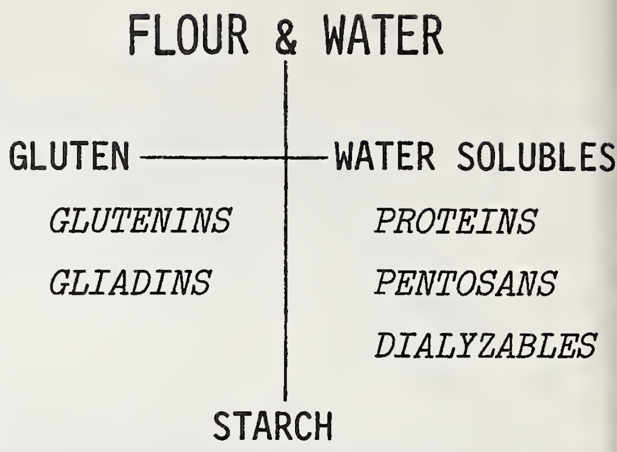
Fractionating Wheat Flour Proteins

Fractionating and reconstituting techniques (slide 8) are used to demonstrate what certain specific gluten proteins do. We fractionate flours of good and poor quality into their important fractions and components, and then interchange one-at-a-time the corresponding fractions in reconstituted flours and bread doughs. All research is focused on the following questions: What is the role of each flour fraction or component? Why are good bread wheats good and poor ones poor?

When we wash the gluten from flour (slide 9), we obtain starch and water-soluble fractions. The water solubles contain such proteins as albumins, globulins, and glyco-proteins. Studies in our laboratory have shown that the albumins and globulins can be omitted in reconstituted flours with no adverse effect in breadmaking; glyco-proteins, however, are essential. Water-soluble proteins are non-gluten proteins that have a higher biological value than that of the gluten proteins. The water solubles soften and condition the gluten proteins and are essential in manifesting their functional (breadmaking) properties. By solubilizing gluten in lactic acid and ultracentrifuging at a high relative centrifugal force of 435,000 times gravity, we obtained glutenin and gliadin fractions.



Slide 8.--Scheme to determine the contribution of individual chemical constituents to the functional (breadmaking) properties of wheat flours.

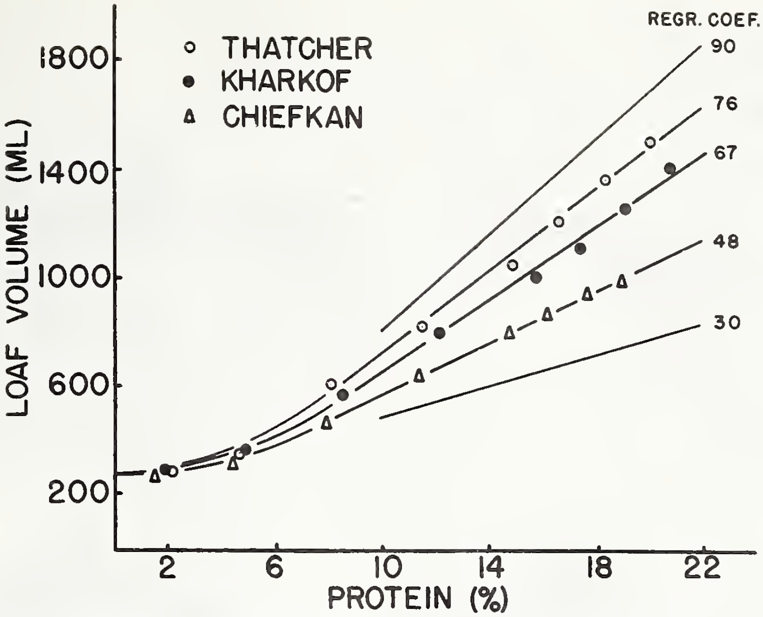


Slide 9.--Scheme to fractionate wheat flour into gluten, water solubles, and starch.

Total Proteins and Loaf Volume Potential

By means of fractionating and reconstituting techniques we can answer basic questions that otherwise could not be answered. For example (slide 10), when gluten, starch, and water solubles were reconstituted to give a relatively complete protein series within poor and good quality wheat varieties, the relation between loaf volume and protein content was linear between about 8 percent and 20 percent protein within each of the three wheat varieties. Below 8 percent protein, however, the relation was curvilinear, and the regression lines for all three varieties met at 0 percent protein and 275 cc. The poor quality Chiefkan, with a regression coefficient of 48 cc/1 percent protein, had a loaf volume of about 1,000 cc at about 18 percent protein. The good quality Thatcher (regression coefficient of 76) had a loaf volume of 1,000 cc at only 13 percent protein. Since the data in slide 10 were obtained, the relation between loaf volume and protein content has been studied for many bread wheat varieties that had poor to excellent loaf volume potentials. For example (slide 11), Sturdy has excellent loaf volume potential, and its sister C.I. 13855 and Kaw have good loaf volume potentials. All three varieties were grown at the same location and received identical fertility treatments. Thus, Sturdy is an excellent example of an old variety that possesses genes for high protein content. Protein contents of the Sturdy samples varied from about 11.5 to 15.5 percent; whereas, those of the other two varieties varied from 9.5 to only 13.5 percent protein.

When the regression lines for all loaf volume and protein content data are combined (slide 12), we have a highly useful and practical fan-shaped family of lines for correcting loaf volume to any desired protein content. The loaf volume and protein content of a single sample of wheat flour establishes its relative protein (gas retention) quality.

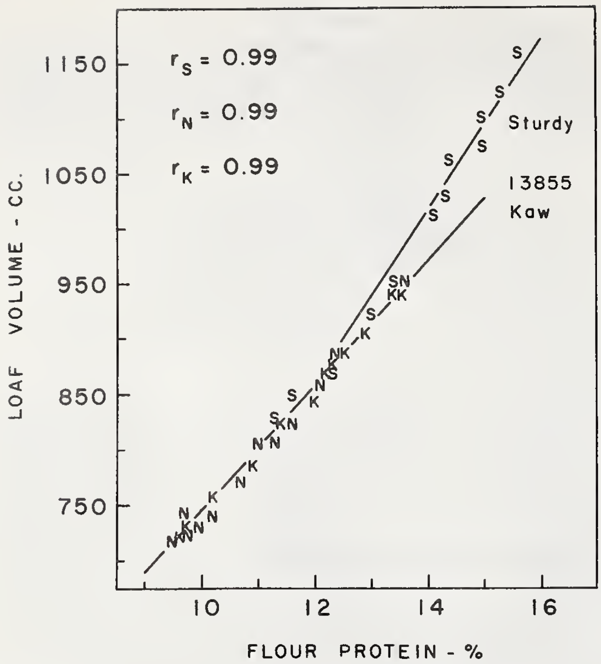


Slide 10.--Relation of loaf volume (100 g flour) and protein content when applying and reconstituting techniques.

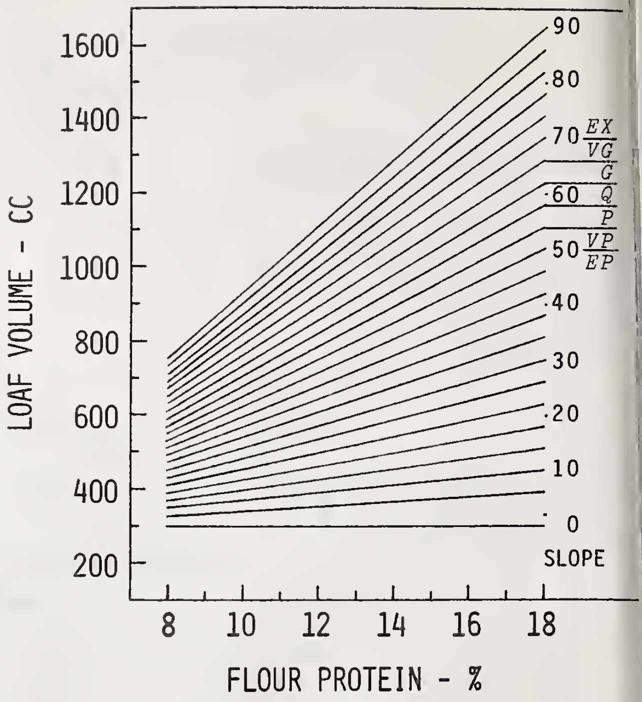
Glutenin and Gliadin Proteins Versus Mixing Requirement and Loaf Volume

In other applications of fractionating and reconstituting techniques (slide 13), the top left mixogram is for the good quality RBS-76 composite flour. The top right mixogram is for the poor quality 76-412 composite. The middle left mixogram is for the reconstituted good quality RBS-76 flour containing the gliadins and low- and medium-molecular-weight glutenins. The middle right mixogram is for the reconstituted poor quality 76-412 flour containing the gliadins and low- and medium-molecular-weight glutenins. The lower left mixogram is for a reconstituted flour containing the glutenins of poor quality variety and the gliadins of the good quality variety; and it has mixing properties essentially equal to those of the poor quality reconstituted flour. The lower right mixogram is for a reconstituted flour containing the glutenins of the good quality flour and the gliadins of the poor quality flour; and its mixing properties are essentially the same as those of the good quality reconstituted flour. Thus, the glutenins control mixing time.

Loaf 1 (slide 14) was baked from the original RBS-76 good quality flour. Loaf 2 was baked from the reconstituted flour containing the gliadins and low- and medium-molecular-weight glutenins of RBS-76. It is significantly larger than loaf 1 because the original high-molecular-weight glutenins were replaced by an equivalent amount of the superior low- and medium-molecular-weight glutenins. Loaf 3 was baked from the same reconstituted good quality flour as loaf 2, except that the glutenins were replaced with those of the poor quality 76-412 flour. Volume of loaf 3, although somewhat smaller, is essentially equal to that of loaf 2, but dough mixing properties (lower left mixogram of slide 13) are essentially equal to those of the poor quality variety (second row, right of slide 13).



Slide 11.--Loaf volume and flour protein content of Sturdy (S), C.I. 13855 (N), and Kaw (K) hard winter wheats grown under various fertility treatments at Temple, Tex., in 1965.

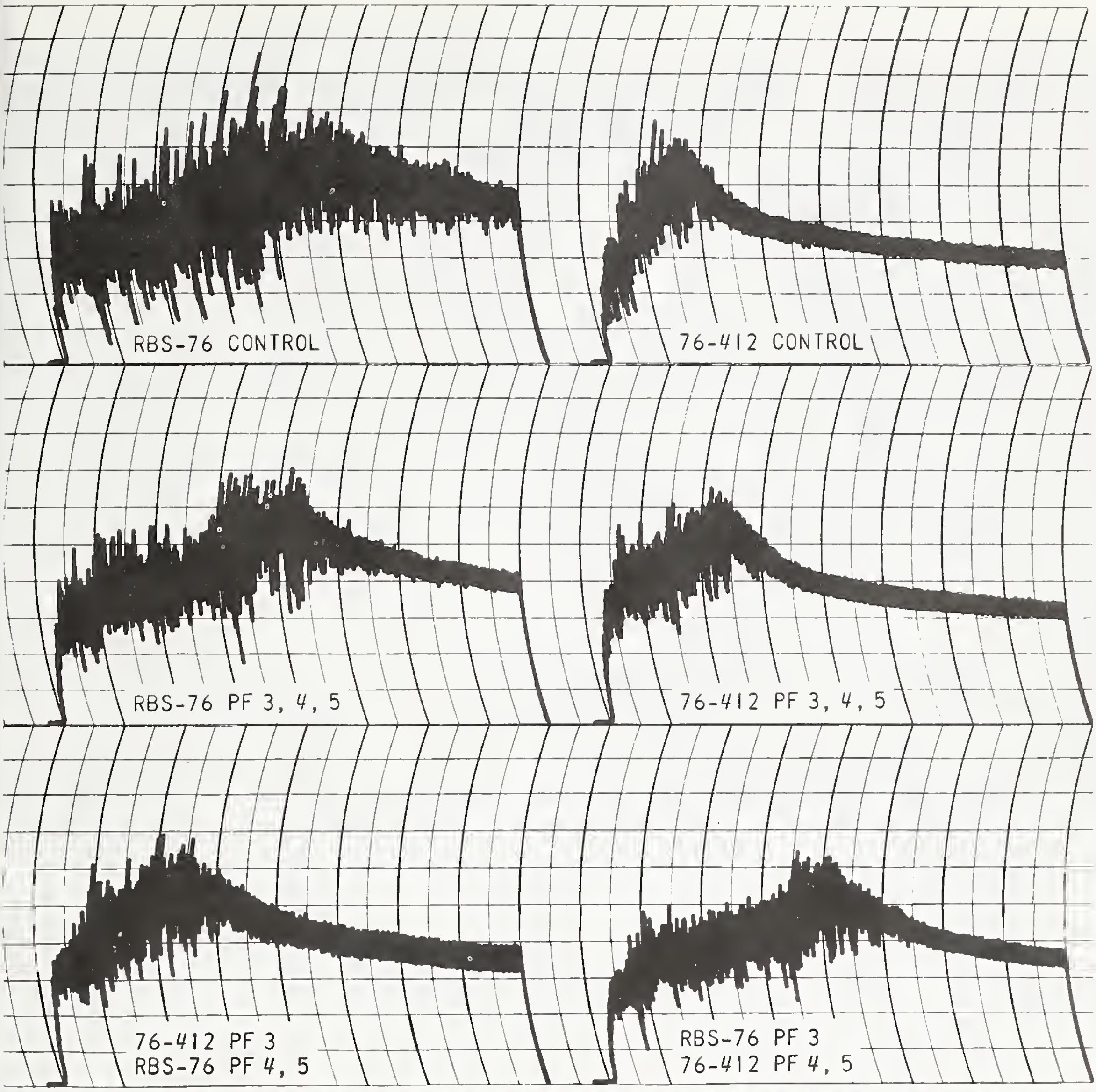


Slide 12.--Loaf volume (100 g flour) versus protein content regression lines for correcting loaf volumes of wheat varieties to a constant protein basis. Slope is rate of change in loaf volume per 1 percent protein.

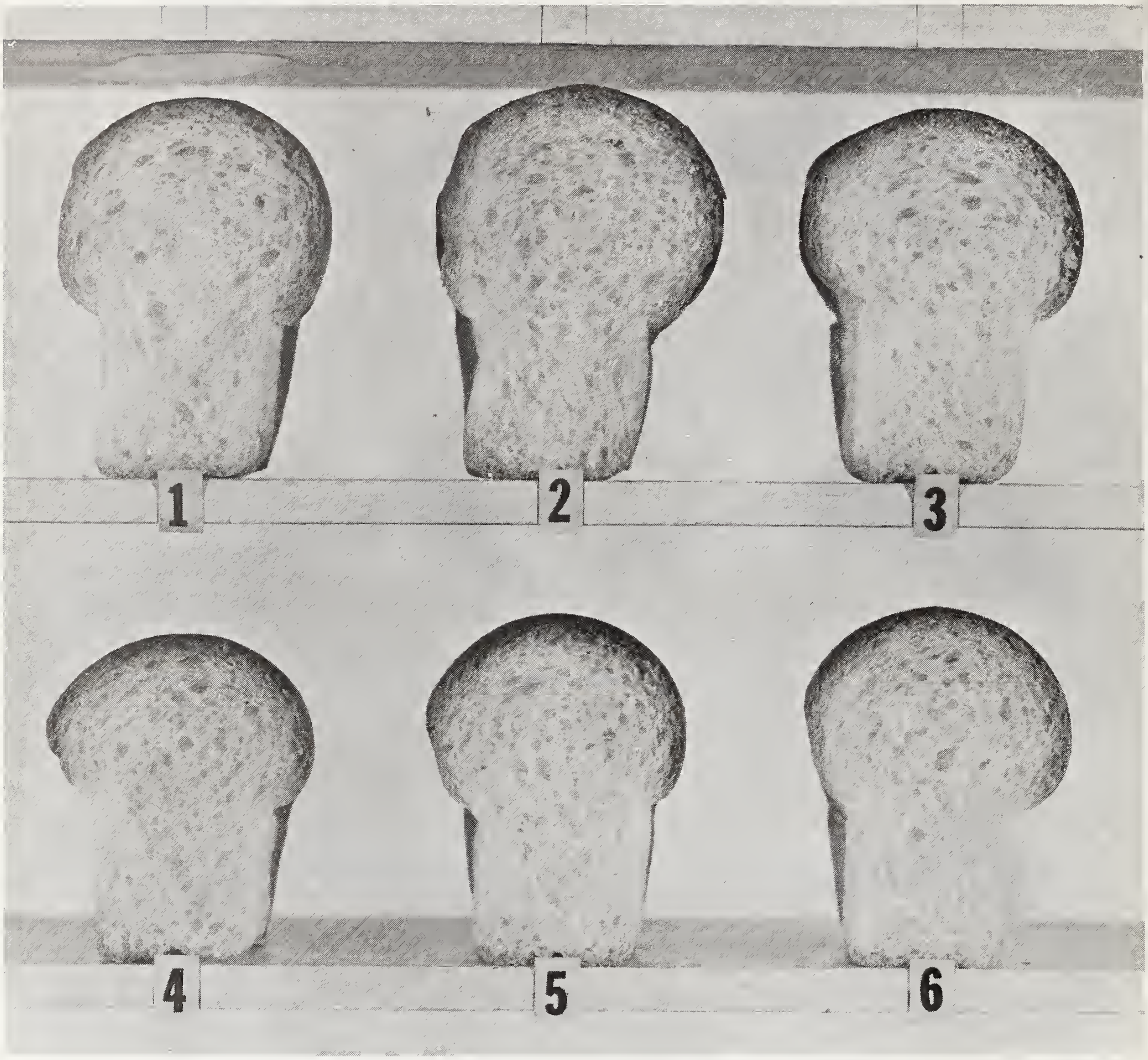
Loaf 4 was baked from the original 76-412 poor-quality flour. Loaf 5, from the reconstituted flour containing the gliadins and glutenins of 76-412, is significantly larger than loaf 4, also because the original high-molecular-weight glutenins of 76-412 were replaced by an equivalent amount of the superior low- and medium-molecular-weight glutenins of 76-412. Loaf 6 was baked from the same reconstituted poor quality flour as loaf 5, except that the glutenins were replaced with those of the good quality flour. Volume of loaf 6, although somewhat larger, is essentially equal to that of loaf 5, but the dough mixing properties of loaf 6 (lower right mixogram, slide 13) are essentially equal to those of the good quality RBS-76 (middle left mixogram, slide 13). Thus, loaf volume is controlled by the gliadin proteins and mixing time by the glutenin proteins.

The gliadin and glutenin fractions were not pure. The glutenins of 76-412 in loaf 3 carried with them small amounts of the poor quality gliadins, thereby accounting for loaf 3 being somewhat smaller than loaf 2. Also, the good quality RBS-76 glutenins in loaf 6 contained small amounts of the good quality gliadins, thereby accounting for loaf 6 being somewhat larger than loaf 5.

Thus, the functional (breadmaking) properties of bread flours (slide 1) are functions of both the quantity and quality of wheat flour proteins. In addition, the glutenin proteins of the acid-soluble gluten proteins control mixing time, and the gliadin proteins control loaf volume and crumb grain.



Slide 13.--Mixograms of good (RBS-76) and poor (76-412) breadmaking flours (10 g). Top row, of unfractionated controls. Middle row, of reconstituted control flours containing low- and medium-molecular-weight glutenins (PF 3), gliadins (PF 4, 5), and starch and water solubles. Bottom row, mixograms of reconstituted flours in which the glutenins of the good and poor quality flours were interchanged.



Slide 14.--Loaf volumes of RBS-76 good (top row) and 76-412 poor (bottom row) breadmaking flours (100 g). Top (1) and bottom (4) left, of unfractionated controls. Top (2) and bottom (5) middle, of reconstituted control flours containing low- and medium-molecular-weight glutenins, gliadins, and starch and water solubles. Top (3) and bottom (6) right, loaf volumes of reconstituted flours in which the glutenins of the good and poor quality flours were interchanged.

DISCUSSION

Pomeranz

The point I would like to make is that while we know woefully little about biochemical systems, some things are known. And the commonly used excuse that we don't know, and it has to be explored more, is not always valid. There are some things that we know and some things are well substantiated. What is happening to the protein in terms of long mixing time? Are we changing the proteins and getting long mixing times?

Karl F. Finney

Differences in mixing time are definitely attributable to differences in the glutenin proteins of wheats.

Pomeranz: Is it the quantity or the quality of the glutenin?

Finney: It is the quality.

Pomeranz

Is there any indication that the pentosans are involved with the wheat flour quality of the proteins?

Finney

Studies in the hard winter wheat lab indicate that certainly the pentosans are an important component of the water soluble fraction which, in turn, is essential to manifest the potential functional properties of gluten proteins. But the pentosans, as well as the entire water soluble fraction, is for all practical purposes as good from a poor quality variety as those from a good quality variety. There are high protein pentosan fractions that are very important in breadmaking, but they are not associated with genetic differences or quality.

Pomeranz

What would you estimate the difference between wheats 10 or 15 years ago and today's wheat in your graph showing quality of protein?

Finney

Unquestionably, hard red winter wheats, today, in terms of loaf volume per unit of protein and overall physical dough properties, are superior to those grown 15 years ago and greatly superior to those grown in the late 40's or early 50's. Today's varieties with only 12 percent protein usually will have as good loaf volume as varieties 25 years ago at 13 to 13.5 percent protein. Thus, the quality of protein today is distinctly superior. It is important to remember that quantity of protein today is definitely a limiting factor from the standpoint of physical dough properties, particularly dough machinability in the bakeshop, so we do need to have a certain minimum level of about 12 percent wheat protein for bakery flours.

WHAT WE WANT FROM WHEAT PROTEIN

Yeshajahu Pomeranz[1]

We have tried to address the problems of the biochemistry of proteins in the wheat kernel. What are these problems? They are what, how much, where, and what proteins do or can be made to do. The problem of what--deals with protein identity; how much--with quantity; where--with site and distribution in the wheat kernel; and what they do or can be made to do--with the function of those proteins in breadmaking.

Not many scientists can resist the temptation to show a few microscopic pictures by scanning electron microscopy (SEM), so I will start with one of them (fig. 1a).

It is an SEM picture of a wheat kernel cross section. The next one (fig. 1b) is again a cross section, a magnification of the crease area.

The next slide is a picture that shows the distribution of proteins; in this particular case, sulfur-containing amino acids in the proteins of the crease area and of the germ. There is a steep gradient of decreasing protein from the subaleurone layer toward the center of the kernel. What this all amounts to is that some tissues are richer in protein than others; protein is highly concentrated in the aleurone, in the outer starchy endosperm, and in the germ.

In general, however, protein is highly associated with a high concentration of ash. This is important in line of Si Jackel's comments yesterday. It would seem that we have to take both ash and protein at the same time, as it is difficult to separate one from the other. In practical milling, this would mean that you can have a higher extraction and higher protein content if you are willing to take the ash and other components that are associated with it. If you go to a lower flour extraction, then you have a drop in protein. The drop is about 1 percent going from the whole wheat to a 75 percent extraction flour. Of course, much can be done in plant breeding to make the drop as small as possible and retain the white flour. There is, however, an inevitable drop that cannot be eliminated entirely.

The next slide is from a paper by Hehn and Barmore that summarizes many of the things looked at in terms of end-use properties (table 1). As Karl Finney emphasized several times, they all center around the fact that the critical factor governing them is protein quantity and protein quality.

---

[1]Director, Grain Structure and Composition Unit, U.S. Grain Marketing Research Laboratory, Science and Education Administration, U.S. Department of Agriculture, 1515 College Ave., Manhattan, Kans. 66502.

Scanning Electron Micrograph of the Wheat Kernel

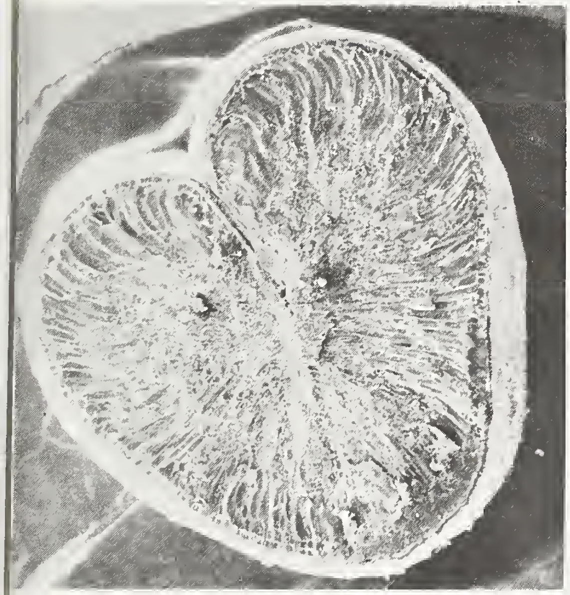


Figure 1a.--Cross section of the whole kernel.

Figure 1b.--Magnification of the cross section through crease area.

We have discussed many aspects of what proteins do. Some of them have to do with functional processing properties, with the loaf volume, and with bread texture. They also have to do with nutritional value and organoleptic properties. Many functional and processing properties related to breadmaking were enumerated by Karl Finney. Additional ones are reduction of losses during processing, freshness retention of bread, and overall consumer acceptance.

Table 1.--Quality characteristics of bread, pastry, and macaroni flour measurable by micromethods

Protein content (%)	11-13	7-9	11.5-13
Flour yield	High	High	High
Ash	Low	Low	Medium
Flour color	White	White	Light yellow
Sedimentation	High	Low	-
Flur absorption	High	Low	Low
Mixing properties	Strong	Very weak	Medium to weak
Loaf volume	Large	Small	Small
Viscosity	High	Low	-
Cookie diameter	Small	Large	-

Source: Hehn, E. R., and Barmore, M. A. 1965. Breeding wheat for quality. Advan. Agron. 17, 85-114.

In addition to the central role that protein plays in end-use properties of dough and bread, there are several points I would like to address briefly. The first one has to do with protein quality and protein quantity. It has been amply demonstrated that protein quality is an important factor. This is certainly true when we are discussing protein quality in plant-breeding programs. I think we should not, however, forget that new cultivated varieties (cultivars) undergo an effective system of plant breeding and screening.

The commercial significance of protein quality in those wheats in marketing channels is substantially smaller than in a plant-breeding program. The cultivars are invariably screened carefully and selected (tailored) to meet well-defined and tight requirements. In the marketplace we seldom deal with single cultivars. The marketed wheats are mixtures; consequently, the significance of quality under those circumstances is by far smaller than in a good plant-breeding program.

Some statements have been made about the significance of visual evaluation of wheat kernels and the significance of vitreousness, or yellow berry. There are several instances when yellow berry is important; for instance, in the production of semolina and farina. In some instances, yellow berry may not be an important criterion, and protein content may be a more reliable index of end-use properties than yellow berry. Some of the poorest varieties that we have known over the years had dark, hard, and vitreous kernels; actually, their looks were their main sales point. Yet, they were inferior in breadmaking. Consequently, appearance leaves very much to be desired, as a precise measure of quality and looks can be deceptive.

In addition, under certain circumstances, there are some advantages to yellow berry. They include better flour yield, lower power requirement, and better air classification. Finally, there is no evidence that protein quality in yellow berry wheat is inferior to protein quality in dark, hard, and vitreous kernels, provided, and this is very important, that everything is expressed on a common protein basis.

I had the opportunity to stress on several occasions the fact that the five most important objectives of plant breeding all over the world are yield, yield, yield, yield, and all the others. This brings me to the next topic: combining high yield with adequate breadmaking quality.

There may be some time before we will reach the ceiling on yields. From what some of the plant breeders were telling us, we are a long way from that ceiling. They also tell us that we have a long way to go to reach a ceiling in building into a wheat kernel all the desirable attributes that we would like to see in the kernel. I hope this is the case because building all desirable attributes into a wheat kernel is the best option.

Plant breeders and cereal chemists are doing everything to build all the desirable attributes into the wheat kernel. Still, genetic engineering of that kernel to meet all those requirements is a challenging proposition. Not only do we want more, but the requirements are changing all the time. Part of the problem is that we want better protein, faster mixing wheats with better stability, and better overall quality. This is quite a challenge. I do believe, however, that the plant breeders are up to it.

WHEAT GRADING FOR QUALITY FACTORS

James L. Driscoll[1]

To this point in the Conference, several well-qualified speakers have addressed various aspects of the availability of quality wheat and its future prospects. Although the emphasis of this meeting is upon protein, Dr. Jackel has pointed out that bakers perceive the problem as encompassing more than this one dimension of wheat quality. This paper does not emphasize any single aspect of quality but is concerned with the description of quality in general. The discussion of wheat grading covers briefly some history to set the stage for where we are today and defines the needs for improving quality description in official inspections.

Federal standards for wheat were first authorized by the U.S. Grain Standards Act of 1916. Prior to the passage of that Act, numerous local terms, sampling procedures, definitions of quality factors, and methods of measurement made transacting business between markets difficult. Grain quality as determined in one market often was not acceptable to another, and inspections accordingly were performed under the rules of the second market for grain shipped into that market.

The uniform standards established under the Act reduced the problems associated with the local standards that previously prevailed. Uniform terminology, methods of measurement for quality factors, and application of inspection techniques permitted buyers and sellers to have confidence in the results obtained in another market.

Because of the diversity of local standards, inclusion of all prevailing methods and definitions of quality factors into the national standards would have been impossible. The national standards that evolved represented the best judgments of all concerned parties with respect to those characteristics of wheat useful for predicting its milling quality. Of course, compromises were necessary.

The early standards for wheat provided a good measure of quality, as quality was understood and evaluated in the early twentieth century. Additionally, quality determinations needed then were not as demanding as they now are. To better understand the reasons for these statements, a look at the markets for flour at that time is useful.

---

[1]Director, Standardization Division, Federal Grain Inspection Service, U.S. Department of Agriculture, 0629 South Building, Washington, D.C. 20250.

Baking bread at home was a common practice in the early 1900's. Commercial bread bakeries were numerous, but each generally serviced a local market. Automation was not extensive. Other forces existed, but two important conclusions can be drawn with respect to quality determinations: (1) a large market demanded the flour known as all-purpose, and (2) both housewives and bakers could tolerate minor variations in performance. Adequate time was available to work with the dough to compensate for minor changes in performance. Minor variations in characteristics such as size of loaf presented no unusual problems since automated slicing and wrapping systems had not been developed to be affected by a non-uniform product.

Flour milling also was less sophisticated. Small mills were more common, having less capability than today to separate flour streams for later blending to meet customer specifications. But greater sophistication was not essential. No need existed for producing a range of customized flours to meet customer requirements.

In the early part of the century, fewer varieties of wheat were available. Much of the wheat in the marketplace usually met the average requirements for the flour produced and sold.

The foregoing should not be interpreted as inferring that there were no requirements with respect to the quality of wheat products. However, the requirements that existed were less strict. In any event, knowledge of the chemical and physical properties of wheat as these relate to end use was less advanced.

In this situation, the quality of wheat was judged on major physical attributes: (1) yield of flour; (2) proportion of damaged kernels; and (3) presence of grain other than the overall class of the lot. Yield of flour was related to the amount of "clean-out" needed (dockage, foreign material, shrunken and broken kernels) and test weight. Although the precise reasons possibly were not known, experience undoubtedly had demonstrated that wheat with damaged kernels would produce less satisfactory flour. And, of course, other grains in the lot which could not be removed also would influence the characteristics of the flour milled from the wheat.

During the past six decades, milling and baking technology, like virtually every other aspect of business, has become more complex. Bakeries now are factories producing thousands of pounds of product per hour. Extensive automation is the rule--all steps from mixing the ingredients to packaging the product are precisely timed. The product must have a high degree of uniformity to meet the requirements of the equipment and satisfy consumer preferences. Uniformity also is needed to keep the process operating at optimum capacity.

Much of the uniformity needed begins with the flour. The baker wants flour having specifications that best meet the operational needs of the bakery and that also meet the desired characteristics of the product. To meet these specifications, millers subject wheat to tests, enabling them to

identify bins that they can process to produce flour with the desired specifications at the lowest cost.

All of these changes in the way business is conducted have accompanied changes in laboratory testing procedures to evaluate wheat. Greater understanding of the functional properties of wheat has led to these advances. The farinograph, the extensigraph, the amylograph, and other testing methods have been developed and used. However, regardless of the array of testing procedures available, the ultimate test of acceptability often must be a baking test.

While we have seen major changes in milling and baking technology in six decades, the standards for wheat remain based in a visual inspection of external characteristics of the kernel and other selected measurements. The present standards essentially characterize a lot of wheat according to a visual appraisal and certain mechanical separations. In other words, visual damage and other grains are the major factors influencing performance of a particular sample. While these may be indicative of potential problems in performance, they are not adequate to meet the needs of all users.

To say that the standards should be updated to recognize end use performance as it is understood today is easy but accomplishing such an objective will not be easy. Unique requirements must be imposed on inspection techniques used to measure quality attributes. These constraints dictate the practicality of changing the standards to measure end-use properties. Among these requirements are:

1. Speed of determination. Often, only a few minutes are available to complete the inspection process, and rarely are more than a few hours available. In export operations, sublots may be completed in as few as 15 to 30 minutes, and results are needed on a sublot before the next is completed if the loading process is to run smoothly. This probably imposes the most stringent constraint upon the time available for inspection. However, results at domestic points often must be available within a reasonable time. For example, a car sampled early in the morning might be offered for sale on the floor of an exchange that same morning. In addition to the actual measurement, down-time between samples is important. An instrument that performs an individual test rapidly but requires several minutes to clean and prepare for the next sample might not be acceptable.

2. Simplicity of operation. Inspection services should be available where needed. We must recognize that domestic inspection services are purely voluntary--the inspection point must have an adequate volume of business to justify its existence. If testing procedures are so complex as to require the services of highly specialized laboratory personnel, thus requiring high salaries, then official inspection services will become less available on a where-needed, when-needed basis. Policies to expand available services are desirable to meet the objectives of the U.S. Grain Standards Act. Policies which tend to restrict availability are less desirable.

3. Precision of test. Sampling of a lot normally results in 2,000 or more grams of material. This is reduced in size for various analyses, and the number of grams used for any analysis is called a work portion. Using the same work portion and repeating the determination several times, there must be a high probability that the results will be within a designated acceptable statistical tolerance. The acceptable tolerance must be equal to or less than that acceptable for truly distinguishing wheat of different quality in use. If the tolerance is so wide that the user only knows that it is somewhere between "barely passable" and "excellent," then the information has little value. Distinguishing between "good plus" and "excellent minus," is necessary at least for some quality measures.

4. Accuracy of the test. The Federal Grain Inspection Service wants to achieve a high level of equivalency among results of analyses performed on different samples from the same lot. In other words, a value obtained at origin should be sustained at destination, on the basis of a new sample, within a small tolerance. The FGIS cannot adopt testing procedures that do not provide meaningful and accurate results among determinations.

5. Standardization. This requirement is related to ease of operation, accuracy, and precision. However, it should be emphasized because inspection services must enable users to correlate inspection results to performance in use. Equivalent results are needed among locations and inspectors. More importantly, if several manufacturers provide equipment to measure the same quality attribute, the FGIS prefers that all available instruments can be standardized to provide equivalent results. Equivalency, or standardization among methods used in many locations, is a primary goal of the Agency.

6. Cost of service. Costs of service must be a primary consideration when new techniques are evaluated. All direct costs must be recovered in the fees charged for inspection services. FGIS itself is not a profit-making enterprise (although direct inspection costs must be recovered). However, many of the licensees offering domestic inspection services are profit-making businesses. FGIS does have an obligation to these licensees--they must be allowed to operate their business so an acceptable profit can be realized. And, of course, the objective of making services widely available is related to costs.

7. Ability to approximate official inspection results. Most producers do not have official inspection services available at the point of sale. Quality reported to them is determined by the operator of the country elevator. In the final analysis, the owner of the country elevator is the one who determines whether farmers will receive the economic stimulus of appropriately determined price to encourage them to produce wheat having quality characteristics deemed important by the marketplace. Quality determinations made at official inspection points can only identify the quality moving in market channels. Unless the producer receives direct remuneration for quality attributes, those quality attributes will not be emphasized in the production of the wheat.

The ability to approximate official inspection results is important if there is an objective of encouraging producers to produce better quality grains. There are two ways to accomplish this end: (1) deploy techniques inexpensive enough and foolproof enough that adoption by country elevators is financially feasible and that reliable and consistent results can be expected by producers, or (2) deploy a technique with high precision and accuracy for official inspection purposes, but for which an alternative test will have somewhat less accuracy. In the latter case, a technique having a statistical tolerance of $\pm$ 0.1 percent between and among samples and inspection points might be employed for official inspection purposes, but another test having a tolerance of $\pm$ 0.5 percent might be used at country elevators. Many country elevators might not have better relative capability to bin wheat, so the quality of the official test would be meaningless to them when purchasing from farmers.

Most available tests for end-use properties of wheat do not completely satisfy one or more of these criteria. Thus, the potential for immediate changes in the standards to reflect end-use quality is limited. But, the situation may be at the point at which significant changes can be accomplished. Just in the past few years, a virtual revolution has occurred in many areas of technology, especially electronics. Miniaturization and incorporation of small computer capabilities of grain testing equipment might be possible. In any event, quality determination in official inspection in the future must proceed from subjective to objective quality measurements.

In conclusion, I would like to leave this thought with you: Official inspection services will probably never be able to do more than measure major quality attributes of interest. Particular, specialized requirements are beyond the scope of responsibility of official inspection. We all know that wheat meeting specialized requirements for one processor may not be totally adequate for the needs of another. However, if the major quality attributes can be measured in such a way that farmers are rewarded for making them available to the market, then the concerns expressed by bakers leading to this conference might be resolved. FGIS wants to do its part to assure that farmers are rewarded for producing grains of the quality needed by the marketplace.

THE PRODUCER'S VIEW

Glenn Moore[1]

I am the president of the National Association of Wheat Growers and a wheat farmer from Baker, Mont., which is a high protein spring and winter wheat area. We have been paid on protein for the last 30 years. The difference in our operation is that we store our wheat on the farm, and we take a protein test before we sell it. I think that we have problems other than protein, and one is the need for better communication within the trade--I mean between the baker, the miller, the producer, the researcher, and the consumer. I think we need to give the researchers longer lead time on the research that we ask for. We have a habit of telling them what we need today, when we should tell them what we need 10 years from now. I would like to tell a story just to make a point.

When I was working on a farm for a percent of the crop back in 1948, we got 15 bushels to an acre and $3.00 for a bushel. That was considered a good crop at the time, and I decided wheat farming was the thing for me. I took 500 bushels of that crop and bought a new pickup.

But things changed the next year. We raised 20 protein wheat, but it only weighed 56 pounds and only made 3 bushels to the acre. By 1960, I built up til I had nine farms, which I leased. One year we had only one-half inch of rain, and the crop was not drought resistant. The next year I had the same nine farms, and a hail storm came along and wiped every one of them out.

But in the early 1960's, there was quite a change in the milling and baking industry, as most of you know. The Old Mule Gold wheat that we were raising wasn't it any more. So we had to make some changes. Well, being a wheat farmer who wanted to produce a quality product, and at that time I belonged to the Montana Grain Growers, we came up with a new variety of wheat that would be acceptable to the industry. We quit the Old Gold and went to a wheat called Cheyenne. It had a higher milling quality than we had been raising but, to our dismay, it wasn't rust resistant.

Anyway, we have progressed in the last few years. We are using some of the new varieties that the researchers have had time now to provide us with. We are using more fertilizer. We are learning how to control our moisture. And right now, with the same amount of rainfall that we had in 1948, we can raise 30 bushels of wheat or more instead of 15. Our only problem is that instead of buying a pickup with 500 bushels, it now takes 2 to 3 thousand.

I think the point I am trying to make is that, as a producer, I am interested in a quality product. But it must also have the other qualities such as rust resistance, shatter resistance, and disease resistance. As an industry, we must tell our researchers what we are going to need 10 years from now and work toward these goals so we can develop wheat with higher proteins while we cure some of our other problems.

We must not forget to communicate with the consumer. As a member of the Montana Wheat Research and Marketing Committee, I had some farm wives tell me they were having trouble making bread, until, finally, we went up into Canada and started buying out Canada. We then asked them to test some of the flour we were buying. We even offered to take the flour from local stores and send it to the University for protein tests. They included Buttrey's 11.5 protein; Gold Medal's 9.9, 10.1, and 10.3; Pillsbury's Best 10.2; Occident's 10.9 and 9.6; and Seratana's 10.2 and 11.4; some IGA, which is 11.8 and 11.7; and Western Family, 10.9 and 11. We were told that the smaller packages were for gravy making, and if we bought it in larger quantities we would get bread-baking flour. So we bought 50 pound bags. Seratana tested out at 11.6 and Gold Medal at 10.

Like I said, this is an area that perhaps we haven't communicated with the consumer enough. Maybe we haven't told them which flours they should buy for gravy and which ones they should buy for cake flour.

---

[1] President, National Association of Wheat Growers, Willard, Mont. 55440.

THE PRODUCER'S VIEW

Robert Brastrup[1]

My call to participate in this conference declared the sessions would focus on the need for emphasis on raising wheat varieties and types with increased protein quality and quantity. And my assigned role to bring that focus about is joining this panel to present the producers' view.

Well, representing growers and particularly those hostile types which abound in Montana, I find this an easy assignment! I have an extremely simple and effective way to emphasize protein in wheat production and it will work anywhere, almost, and especially in Montana. All you have to do is pay the producer an assured, substantial, protein premium!

The marketplace--not these conferences, not quality council meetings, not extension service bulletins, not county agent exhortations--dictates the producers' decisions as to which variety to plant.

A new variety <u>can</u> bring about an increased yield. A new variety <u>can</u> bring about higher protein. But the general corollary subscribed to by most dirt farmers simply says: Higher yield brings lower quality and higher quality brings lower yield.

If the wheat processors are unwilling to pay for protein, which for this purpose I'll equate entirely with quality, then the farmer is going to opt for the first half of that corollary. He'll take the higher yield and forget the quality. If you tell him "wheat is wheat", he'll take you at your word--and he'll give you whatever wheat gives him the most bushels and the most dollars.

We're always concerned when the quality of Montana's wheat deteriorates in protein or other factors, and we're concerned over the long term--not just the way the individual farmer shows concern based on short-term economics.

But let me give you an example of what I'm saying about cause and effect and about yield and quality. Go back a few years to when the Russian wheat sales took over 400 million bushels of this country's wheat. Carryover stocks in the United States were halved, people stopped talking surplus, and some even said we no longer had enough wheat to feed the hungry world. A few alarmists delcared we might not even be able to feed ourselves.

---

[1]Executive Secretary, Montana Wheat Research & Marketing Committee, P.O. Box 3024, Great Falls, Mont. 59403.

India and China contributed to the "shortage" atmosphere when they made unusually large purchases of U.S. wheat, cutting the carryover even further. Suddenly, our traditional customers overseas, such as Japan and Western Europe, had to bid furiously for U.S. wheat they always had counted on to meet their supply needs. And I want to emphasize that they were bidding for any wheat they could get!

You see, I'm going back to what I warned you about a few minutes ago. Because of a short supply market--or certianly interpreted as such by the buyers--wheat was wheat. It really didn't matter all that much if you had 15 percent dark northern spring, ordinary protein, or even white wheat. The price differential for proteins was practically nonexistent.

That's when wheelin'-dealin' private wheat breeders came rolling across the plains with their new varieties. And they had a pretty convincing sales pitch. All they had to do was point out to the farmer something he already knew--that extremely little was being paid in the way of protein premiums. And right outside there in the yard, in their Medicine Show wagon, they had the latest cure-all, a new variety that was a really high yielder.

You know, those farmers like to refer to us desk-types in town as pencil pushers, but absolutely nobody I've ever known pushes a pencil more or faster than a farmer figuring out how he can gross more money! That's exactly what they did then, and they planted the higher yielding varieties regardless of the lower protein or milling quality.

We have one wheat farmer up there in Montana who is a very quotable guy. His name is Ted Schwinden, and he came off a farm at Wolf Point in the spring wheat country of eastern Montana as the president of the Montana Grain Growers Association, then as our commissioner of State Lands, and now our lieutenant governor. In remarks to the Montana Wheat Quality Council about a year and a half ago, which I have been using liberally here today, he put the problem into perspective in his usual succinct manner. Schwinden said, and I quote: "Farmers argued that premiums weren't being paid for higher proteins and the trade argued that discounts weren't being taken on lower proteins. Well, whether the floor moved up to the ceiling or the ceiling moved down to the floor really didn't matter because the results were the same."

As Schwinden explained, based on short-term economics, individual farmers were right in maximizing their yields at the expense of higher quality.

After those earlier seventies years, when wheat supplies became more plentiful and protein premiums were being paid on a meaningful basis again, those undesirable varieties of wheat, which had sprung up so quickly, faded out of the picture nearly as rapidly as they had come onto the production scene. There is absolutely no doubt that protein premiums were the significant factor in reducing the plantings of those lower quality wheats.

Admittedly, there are a lot of other factors in the over-all yield and quality situation. There's the weather which, unfortunately, neither the producers, the millers, nor even the government has any control over. With favorable moisture conditions, such as we had this season, the yield and

production skyrocket. But we all know about the inverse relationship between the amount of moisture and protein levels--moisture up, protein down.

Fertilizer, too, has a direct and an indirect effect on yield and protein. Because the farmer is always looking for a way to cut costs, nitrogen application has not always been at the optimum level to maximize protein. Also, the fertilizer costs too much or the protein premium and the marketplace or both do not offer sufficient encouragement. And, of course, there's not always a fertilizer response in terms of protein either.

Then there are our friends overseas. And, as a producer representative, I do mean our friends! They also know the desirability of high protein and often are willing to pay good money for it with a resulting export movement that limits the supply to domestic processors even more.

And there are tillage practices that affect protein and yield, summerfallow, cleanliness of fallow, and rotation.

Then, too, we can't ignore research concerning not only protein quantity but also protein quality, which indicates there is not always direct correlation between the percentage of protein and the milling and baking quality. When conclusive information shows that a certain variety has more desirable characteristics and is more valuable to the miller, the baker, or both, I am confident farmers can be moved in the direction of that variety.

I'll defer to a characterization Schwinden used: "Farmers are individualists, but they're equally realists! They compete to be the best producer in their area, they prize those who have the best crops and the healthiest stands, but most of all, it's who gets the top dollar!"

That's why you'll see new, improved varieties of wheat in broad use as fast as they are released. The capability of a farmer to adapt to a new variety, if it proves promising and rewarding, is remarkable.

In closing, I'll go back to my main theme. Protein is not all that important of and by itself to a producer--not the way it is to a processor. Protein is important to a producer principally if it means more profit from his production.

So, you don't need to worry about variety, quality, and protein--not if you pay! Our farmers will produce!

But, for those millers and bakers who entertain thoughts of "wheat is wheat" and no premium for protein, let me refer you to a quote from Samuel Butler, an acid, but accurate English satirist who wrote in the 1600's. Butler, who liked to popularize proverbs said:

"As the ancients say wisely,
Have a care of the main chance,
And look before you leap,
For as you sow, ye are like to reap."

Thank you for hearing me out and for your interest in the producers' view.

PROTEIN CONTENT VERSUS ECONOMIC RETURNS

Winston Wilson[1]

On behalf of all wheat producers I would like to express our appreciation for the opportunity to participate in this conference. To my knowledge this is the first conference in several years that has included such a broad spectrum of the industry.

Wheat protein quality is certainly by now a very familiar theme. Quite often in a meeting of this type, when your particular allotted time on the program arrives, you discover that a similar speech already has been made ably by previous speakers.

I think the main idea that we, as wheat producers, want to convey to the other segments of the industry represented here today is that we are as much, or more, concerned about the quality of our product as any producer of raw materials in any industry. However, as in any other production process, quality, and in this case specifically protein--higher-level protein--increases per unit cost of production significantly, either through increased inputs, reduced yields, or both.

The point has been made, emphatically, that the key to increased protein levels is economic. Certainly, we have high protein varieties. Technology for increasing protein levels, by increasing fertility, is available if the economic justification is present. But there are certain other factors that I would like to consider for a moment.

One of the points left hanging yesterday was if protein premiums are being paid why are the farmers not receiving them? I think we can take a look at our marketing system and determine why this has not been happening in the past as often as it should have been.

Most of the grain in the United States, wheat in particular, first enters the marketing chain at the country elevator level. But country elevators are not geared to purchase wheat on a protein basis. Before the new infra-red analysis for protein, there was no workable method of testing. The old Kjeldahl method was much to cumbersome and complicated for the average country elevator operator. There just has not been a method by which protein could be determined in particular loads of wheat as it arrived. In many cases physical facilities for protein isolation were not available either. Such facilities, of course, require some capital investment on the part of the country elevator operators, but because of the lack of incentive to test for protein, these facilities are not available. This problem is greater in the southern Great Plains areas of Texas, Oklahoma, and parts of Kansas where commercial storage is used almost extensively.

In areas of own-farm storage, some protein premiums have been paid to farmers regularly, because they have the opportunity to determine protein levels in their farm storage wheat before hauling it to country elevators. These are

---

[1]Vice president, National Association of Wheat Growers, 1300 Cain St., Quanah, Tex. 79252.

existing problems, which can and are being overcome at this time if a consistent meaningful protein premium could be depended upon.

We realize that protein is subject to supply and demand. But variation of 50 to 60 cents per bushel to a negative premium, which was present in the market recently in Kansas City, is too variable to use for intelligent decision making for production inputs, capital investment, and handling facilities. Some minimum, dependable levels of return must be assured if the necessary expenditures are to be made.

A second area of consideration must be the total market demand. Most of our discussion to this point has centered on the domestic market. However, normally about 60 percent of our annual disappearance goes into export markets. Certainly, the European Economic Community, Japan, and the Philippines are purchasers of high-protein wheats, but other buyers, particularly the developing countries, where the greatest potential for market growth seems to lie, are not particularly interested in high-level protein. They are, for the most part, interested in the most reasonably priced food product. Certainly we must produce for this demand, as well as the demand for higher-priced, higher, protein wheats for the domestic market. We must compete in the world market on a price basis as well as quality basis.

A third consideration must be looked at. Farmers are by nature a suspicious and skepical group of individuals. And I think we must ask ourselves what the long-run results of significant increase of average protein levels might be to them. If we were successful in boosting our protein levels, would some other quality factor suddenly become a major price determinant? We have had some unhappy experiences with this type of situation in the past. One that comes to mind is the problem of the yellow subclass.

About 3 years ago, this was a major problem in much of the hard-winter area. Technical people generally agreed that the yellow color had little or no effect upon milling and baking qualities, so the yellow subclass was eliminated as an official grade. Since that time, particularly in the early part of this marketing year, we have seen substantial discounts for the Dark Hard Vitr (DHV) counts below 40 percent despite the fact that, in many cases, the low DHV wheats often were fairly high-protein wheats. I think in the back of our minds we wonder, once higher proteins become a norm, would this quality suddenly cease to be a price factor?

In summary, I would say that the wheat producers are very concerned about protein levels, but this concern will only be acted upon when the economic returns justify the added production costs.

DISCUSSION

Glen Moore

I think we must realize that farmers pay for a lot of the research that has been done, and we appreciate that the Kansas Wheat Commission has been involved in that as well as Kansas farmers. This has happened in a lot of the other states. Farmers are paying now through their commissions, and the commissions are not that well funded. But it does help some. I like meeting together and communicating on our common problems. Let's continue working together.

Wheat Protein Content--A Miller's View

William C. Mailhot[1]

My remarks are not necessarily the thoughts of everyone within the milling industry but rather some facts and observations of my own. First, let me endorse the programs being followed by the U.S. Department of Agriculture and wheat breeders in their efforts to increase natural protein levels in new wheat varieties.

Increased protein levels are highly desirable; however, we must continue to look at overall wheat quality, not protein quantity by itself. Some wheat varieties released in recent years have caused severe problems for both the milling and baking industries. Furthermore, too many varieties may be available to properly handle and blend for satisfactory end use. Comments on flour quality most often made to the milling industry by bakers concerning adequate protein levels for bread and roll production include poor absorption, nonuniformity, high-mix requirements, dough toughness, protein toughness, lack of tolerance to high-speed continuous mix, and mix time always at maximum.

I am not certain that increased protein levels in Hard Red Winter (HRW) wheat will reduce the number of comments like these that we receive from bakers. When the mill chemist looks for wheat lots that will satisfy the needs of the bread and roll baker, he looks for these quality factors:

Flour: Milling potential
Protein
Yield
Ash
Granulation

Bake: Absorption
Mix time
Mix tolerance
Dough characteristics
Loaf volume
Crumb grain
Overall baking quality

I might offer a couple of thoughts on what is required to satisfy the wheat grower, the miller, and the baker. Some of these research and wheat breeding goals should include

[1]Director, Quality Control, Sperry Division, General Mills, Inc., 9200 Wayzata Blvd., Minneapolis, Minn. 55440.

Improved quality (includes protein quality and quantity)
High yielding varieties
Resistance to pests and diseases
Tolerance to management practices
Variety adaptation to climate and soil conditions
Early maturity--consistent yields

To get to the question of what is available now, table 1 shows wheat production for crop years 1960 through 1978. As of June 1978, there was about a 1.2-billion bushel carryover and slightly more than 1.8 billion bushels have been harvested this crop year.

Table 1.--U.S. Wheat Production

Crop Year	Acreage planted	Acreage harvested	Yields per harvested acre	Production
		(million acres)	(bushels)	(million bushels)
1960	54.9	51.9	26.1	1,354.9
1961	55.7	51.6	23.9	1,232.4
1962	49.3	43.7	25.0	1,092.0
1963	53.4	45.5	25.2	1,146.8
1964	55.7	49.8	25.8	1,283.4
1965	57.4	49.6	26.5	1,315.7
1966	54.4	49.9	26.3	1,311.7
1967	67.8	58.8	25.9	1,522.4
1968	62.6	56.0	28.5	1,576.3
1969	54.3	47.6	30.7	1,460.2
1970	49.6	44.1	31.1	1,370.2
1971	54.6	48.5	33.8	1,639.5
1972	55.4	47.8	32.6	1,559.0
1973	59.0	53.9	31.6	1,705.2
1974	69.8	65.5	27.4	1,793.3
1975	75.1	69.6	30.9	2,134.8
1976	80.2	70.8	30.3	2,142.4
1977	74.8	66.2	30.6	2,025.8
1978	66.3	56.5	31.5	1,817.0

Available stocks of HRW wheat and Hard Red Spring (HRS) for flour in bread and rolls that require good quality protein are shown in table 2.

Table 2.--Estimated 1978-79 wheat supply-use by class

Supply-use	HRW	HRS
	(million bushels)	
Stocks--6/1/78	621	345
Production	842	385
Supply	1463	730
Exports	620	180
Domestic Use	356	154
Total use	976	334
Ending Stocks 5/31/79	487	396

Of the 842 million bushels of HRW produced, about 665 million was in the five states of Texas, Oklahoma, Kansas, Nebraska, and Colorado. Average protein levels (corrected to 14 percent moisture) are shown in table 3 for 1967 versus 1978.

Table 3.--HRS wheat survey (1967 versus 1978)

State	Production		Average protein (14 percent moisture)	
	(million bushels)		(percent)	
	1967	1978	1967	1978
Texas	55	57	13.7	13.8
Oklahoma	91	151	12.9	12.7
Kansas	230	309	12.8	11.6
Nebraska	98	91	12.1	12.2
Colorado	37	56	11.2	11.7

I do not have a breakdown of protein levels by crop year for all states, but table 4 does show average wheat protein levels (corrected to 14 percent moisture) for the State of Kansas for crop years 1965 through 1978. The interesting fact is the wide range in crop average protein over these years.

Table 4.--State of Kansas average wheat protein levels

Year	Protein
1965	11.1
1966	12.0
1967	12.8
1968	11.5
1969	10.6
1970	11.2
1971	11.7
1972	11.3
1973	10.6
1974	10.9
1975	11.0
1976	11.3
1977	12.1
1978	11.6
Range (1965-1978)	10.6-12.8

Another comparison worth noting is the yield per acre versus average protein level shown in table 5.

Table 5.--HRW wheat, Kansas crop average

Period	Yield	(14 Percent Moisture Basis) Wheat protein
	(bushel per acre)	(percent)
1948-59	17.1	12.1
1960-69	24.2	11.4
1970-77	31.6	11.3
1977 crop	28.5	12.1
1978 crop	30.0	11.6

Table 6 indicates the range in protein levels for the State of Kansas comparing averages for crop years 1967-76 with those for crop years of 1977 and 1978.

Table 6.--HRW Range of Kansas Protein (14 percent moisture basis)

Period	Protein levels					
	Under 9.7	9.8-10.5	10.6-11.5	11.6-12.5	12.6-13.4	13.5 and over
	Percent	Percent	Percent	Percent	Percent	Percent
1967-76	4	28	36	21	8	3
1977 crop	1	2	26	47	22	2
1978 crop	0.2	6	41	42	10	0.8

When talking about available wheat and protein for bread and roll type flours, we must recognize that HRS wheat produced this year was about 385 million bushels with a carryover of 345 million bushels.

To summarize, I would suggest the following:

1. Continue to encourage wheat breeders and the U.S. Department of Agriculture to consider better protein quality and quantity in new HRW wheat selections.

2. Looking at available stocks and protein levels of HRW and HRS, there appears to be adequate protein to protect the interests of the miller and the baker. With 1,463 billion bushels of HRW and 730 million of HRS, we should be able to find suitable stocks with adequate protein.

3. The milling industry should be able to give the baker any wheat flour he requires; however, we must pay the grower for wheat, pay for processing wheat into flour, and make a reasonable profit in order to stay in business.

4. From a nutritional viewpoint of the American diet, about 20 percent of both calories and protein come from foods made from grains. Of these grain products consumed, about two-thirds are in the form of flour-based products--especially breads and rolls. These not only contribute calories and protein but also significant amounts of several other important nutrients.

THE EXPORTER'S VIEW

Robert W. Kohlmeyer[1]

During the course of this conference, you have heard a number of views on wheat protein. You've just heard the miller's view. You've heard the baker's view, the breeder's, the producer's. Now, I've been asked to present the exporter's view.

I appreciate the chance to present my thoughts on wheat protein from my own perspective. But I'd like for you to bear in mind that all these views are interlocking--that the interest of all represented here tightly mesh.

That's especially true from the exporter's standpoint. Exports have become very important--even essential--to a healthy agricultural economy. Agricultural exports also have become very important to the general economic well-being of this nation.

You know the economic problems. They're on the front page all the time. The dollar is falling. The trade deficit is climbing. Inflation is soaring. And worst of all, the thrust towards protectionism is growing.

We can't efficiently produce all the goods and services we need. We must depend on products from abroad.

And that dependence is growing--to about $147 billion worth last year. This nation spent about $44 billion on oil alone. What we sold abroad just didn't measure up to what we bought. That gave us a trade deficit of nearly $27 billion and a declining dollar. The problem is not with U.S. agriculture. Or, put another way, where would we be without U.S. agricultural exports? Our trade in agricultural exports shows a net surplus of $13 billion during fiscal year 1978. Imagine! A $27 billion trade deficit inspite of a $13 billion agricultural surplus. Incidentally, I estimate that U.S. wheat exports contributed about 30 percent of that agricultural trade surplus.

---

[1] Senior merchant, Commodity Marketing Division, Cargill, Inc., 15407 McGinty Road, Minnetonka, Minn. 55440.

The Value of Exports

Agriculture represents one of our best tools for putting U.S. trade patterns back in balance. We have worked steadily toward increased grain exports. In the last 25 years, U.S. grain exports have increased fivefold and are now running about 3½ billion bushels annually.

That international market is obviously of major importance to the U.S. farmer. About 1 in every 3 bushels of grain grown in this country is exported.

And foreign markets are especially important to the wheat producer. The United States had produced more than 2 billion bushels of wheat in each of the last 3 years and about 1.8 billion bushels this year. More than half that wheat now goes for export--about 55 percent last crop year, and perhaps 60 percent will be exported this year. We're talking about more than 1.1 billion bushels of wheat. That's an enormous market for the U.S. wheat grower.

Exports are extremely important to the farm economy. And, yes, we have managed to increase our share of world markets. But we can't get complacent about that business. Competition is razor-sharp in the world marketplace. If we are to continue to get the business, we must continue to provide customers with what they want, when they want it, and at a price they are willing to pay. And that brings us squarely to the subject of this conference.

Hard Practicality

In my business--grain merchandising--young merchants quickly learn the fine art of facing up to hard practicality. And they learn to do that sooner, rather than later.

Now, I'm going to ask you to face up to hard practicality. I'm asking you to face the fact that efforts to improve wheat quality may have an adverse effect on exports--those same exports that have become so important to the economy generally and agriculture specifically.

Anything that damages the export potential of U.S. wheat hurts the wheat economy. And that hurts the grower, the miller, the baker, the exporter, the wheat scientist--all of us here.

The fact is, the majority of buyers in the world market are not especially interested in high protein. And they certainly are not interested in expensive protein.

The fact is, the majority of customers in the world market are price buyers. I define "price buyers" as those customers who are not willing to pay a premium for hard wheat of more than 11 percent protein or for spring wheat of more than 13 percent protein. I also include those buyers--and they are many--who want to buy the cheapest U.S. grade number two wheat without regard to class. Without caring whether it's soft red winter, hard red winter, white wheat, or northern spring wheat.

The leading customers for U.S. wheat--the Soviet Union, Japan, Brazil--are all predominantly price buyers. In the 1977-78 marketing year, we estimate that more than 70 percent of U.S. wheat exports went to buyers who were not interested in higher than 11 percent protein.

That's not to say that quality is not a consideration in the marketing of wheat. Domestically, as you well know, protein plays an important part in the U.S. flour market. And there is a market for higher-quality U.S. wheat abroad--in the United Kingdom, in the high-protein segment of Japanese trade, in the European Community to the extent it imports, in Saudi Arabia, and other specialty markets.

But that 30 percent of the wheat market is quite static and stable. Growth is tied principally to growth in population. The greatest growth potential lies in the other 70 percent, the lower quality market. Demand there is propelled not only by population growth but also by dynamic economic growth.

I predict that that 70 percent will grow. The rise of the People's Republic of China as a wheat customer will increase the percentage. They are price buyers in the purest sense.

In the case of the Soviet Union, for example, cheaper wheat is especially attractive. Remember that the U.S.S.R. produces 50 percent more wheat than the United States and more than all of North America. It's a simple matter for the Soviets to blend large amounts of imported lower-protein wheat with some of their own higher-protein product. Naturally, they are buying price, not quality.

Then there are the developing nations. While there is a need for more protein in poor nations, the greater need is simply for more food. Naturally, they want the most bushels they can get for their limited funds. They, too, are predominantly price buyers. The European Community, currently, is aggressively serving this large market for cheap wheat. So are Argentina, Turkey, and the Balkan countries, among others.

The greatest potential for growth in U.S. wheat exports lies with developing countries and state-controlled economies. I think it is safe to say that both groups will continue to seek the "cheapest" wheat.

In the case of the Asian market, buyers often want wheat offering the color and flavor preferred for the noodles Asians enjoy. They can meet that need with lower-protein wheat. The Asian market is developing rapidly. The Republic of Korea, for example, more than doubled its wheat imports between 1966 and 1976, and that increase has been in the form of low protein hard winters and white wheat. A few days ago I noticed an article in a trade journal suggesting that Indonesia would substantially increase its imports of low protein hard winter wheat because its milling industry had learned to produce a satisfactory flour from this type of wheat. The article carefully pointed out that Indonesia would not reduce its use of high protein spring wheat, used to blend with Australian standard wheat. But clearly the increase in wheat use, dramatically projected by the reporter, will be in so-called low quality hard winters.

In the Middle East, lower-protein wheat is adequate for the flat breads favored there. And you certainly are aware of the milling advances around the world that allow the baking of higher-quality bread from lower-quality wheat.

Soft red winter wheat is an example of the price market phenomenom. Usually the amount grown in this country far exceeds the amount consumed here. For a variety of reasons it tends to seek export markets that will reduce supplies to an economic carryout level. To do this it traditionally drops to a price level below other classes of wheat that encourages its use. Then its prices rise as export volume increases to the point that other classes may become competitive with it. The point is, this movement occurs because of supply and price demand, not because of any perceived quality differences.

The world is full of price buyers. And efforts to improve quality--as we define it--that increase costs will make the United States less competitive. Our major customers will take their business elsewhere.

Now the increased costs I'm talking about might be "absolute" increases, that is, higher per-bushel prices. Or, increased costs might come in the form of reduced yields. But the fact remains, increased costs undercut U.S. competitiveness in a very competitive marketplace.

Enhancing Competitiveness

Other exporting nations are beginning to recognize this. In spite of their ongoing brags about quality, the Canadians have--rather quietly--taken a definite tack toward enhancing the competitiveness of Canadian spring wheat. The Canadians have decided that they must be able to sell Canadian spring wheat that is competitive in the world cheap wheat market if they are to capture their share of that growing demand. Almost every year they sell large amounts of grade 2 or 3 Canadian Western Red Spring Wheat of 13 percent protein or higher into the "price market."

They are beginning to encourage increased production of high-yield, lower-quality wheat such as GlenLea. And they are now selling their "No. 1 Utility Wheat" in the United Kingdom, in Brazil, and in the Soviet Union for milling purposes.

All of my experience in the grain trade and all of my instincts as a businessman tell me that they are doing the right thing. The economics are simple: improved yields equal reduced unit costs; reduced unit costs equal increased sales.

And any effort that doesn't increase yield--no matter what quality goals are achieved simultaneously--will be self-destructive.

Self-destructive. Sounds a bit harsh, doesn't it. Well, it's a harsh market. For all our efforts to increase grain exports, the United States is still a residual supplier. We don't have our buyers over a barrel. We get the bottom of the demand barrel. In fact, U.S. grain exports amount to less than 10 percent of the grain consumed outside this country.

American grain farmers don't need fewer export sales. They need more export sales. Cut those sales back, and grain growers--wheat growers--lose money.

We can't let that happen. All of us must work together--on the trading floor, in the field, in the laboratory, in Washington, everywhere--to broaden markets for U.S. farm production.

In your own efforts, I urge you not to lose sight of the fact that a strong U.S. agricultural sector is essential to a stronger economy. And I urge you to temper your goals with hard practicality. You as scientists and researchers, we as merchants and exporters, can, with the ultimate help of the American wheat producer, stay in the thick of the wheat export battle. If we can meet our customer's needs, we can reap the benefits of growing agricultural exports. When you consider the alternatives, what choice do we have?

DISCUSSION

William J. Hoover

What effect, specifically, will the introduction of a protein test for export wheat have as part of the grading factor?

Robert H. Kohlmeyer

In terms of increasing the demand for protein wheat, I say that it will have little, if any, effect. It will be another added complication to the marketing process for U.S. wheat. I am not sure that I would favor the advent of a uniform protein requirement as part of the wheat grade because, it seems to me, it serves a relatively limited market and consequently its use may, in turn, be limited, as far as protein is concerned, in the world marketplace. I think this year is probably the best example I can think of in my experience of the relative inelasticity of high protein wheat demand in the export market. Available supplies of high protein wheat in this country, as a percentage of the total, have probably never been larger--considering that this crop was a relatively high protein crop and considering that a substantial amount of the carryout from last year was high protein.

I have never in my experience seen protein premiums in hard winter wheat or, for that matter, spring wheat, as narrow as they are this year in the export market. And yet I am sorry to say I cannot see any significant example of buyers in the world market being willing to take advantage of those narrow protein premiums to step up the protein content and, therefore, the quality of the wheat they buy. As a result, I think I am forced to conclude that a protein test included as part of the grade requirement might, in fact, not accomplish a great deal but, would rather, add some additional expense and possibly some additional confusion to the marketing process.

Hoover

One Sunday last spring, I went to Kansas to take part in a workshop for the Catholic Church there for the World Food Situation. A group of people were sitting in the back row grimacing at a lot of the things I said. When it came time for the discussion, it turned out that they were farmers who were very upset about the price they were getting for wheat. They thought that I was a tool of the grain trade, and I was accused of being the person that was causing their low wheat prices.

Now, you folks who are in the grain merchandising business, and are looked at generally by producers as not their customers but their enemy, must face this all the time. I think that our very system of marketing grain, and particularly wheat, in the United States is being challenged by many. What are you doing about it? What are you saying to people about it?

Kohlmeyer

This is an ongoing problem. It is a problem, of course, that became accentuated with the precipitous price decline that took place about a year ago. It is a problem that is 40 cents a bushel less severe than it was 12 weeks ago. But that in itself is not an answer to the problem.

It is true we are considered by at least a segment of the American farming community as an enemy. We don't think we are enemies. In fact, we consider that our interests and the interests of the American grain producers run parallel courses. Our problem has been in trying to get this message across to those to whom it means the most. I must say, I think as an industry we have done a poor job of doing that.

We probably were lulled into the complacent sort of situation by a period of relative high grain prices that took place starting in 1972 and continuing for a couple of years thereafter. We did not adequately prepare ourselves to face this kind of challenge--which was inevitable during periods of low prices. But we are trying, at least, as far as Cargill is concerned, and I think this is more or less representative, to take some steps to get the message across that we are not torpedoing the farmer; that we do not feel we are the cause of his relatively lower income; that, in fact, our corporate income history shows it tends to parallel that of farm income in the sense that when farm income is good we find our corporate income is also at a relatively higher level. Conversely, when farm income is lower, so is our corporate income. That is the kind of message that is very difficult to get across. We are taking some steps that I would describe as a public relations effort. We are making an effort to speak out on the issues. We are making an effort to try to defend our marketing system which, in my opinion, has no euqal in the world. We are also attempting to present this message in a more formal way.

About 3 months ago, we embarked on a corporate advertising campaign because we discovered in a number of surveys we commissioned in the last 18 months that Cargill's reputation was not particularly good among people who thought they knew what Cargill was all about. Perhaps more important, there are a large number of people both in the agricultural sector and in the urban sector who have no idea what Cargill is. So we have undertaken an ad campaign, which uses

magazines, as well as TV and radio spots, as a two-pronged effort to try to pass our message on, first of all, to the agriculture community, particularly to include producers, and also to the urban dwellers who, in our view, do not recognize the value of the agricultural contributions. It is too early to tell if that campaign is going to have any success. We will try very hard to evaluate it starting about a year from now, but I think that we are going to have to feel our way.

We are in an area that we have really never been in before. We are not professional public relations types by and large. I am certainly not, and if it is a little hard for me to consider the subject of natural science, think how hard it is for me to consider the subject of a successful advertising campaign. I am simply not qualified, but corporately we are just going to have to struggle along. I think too that we have as an industry suffered through a number of difficult events, which cast a pall on our industry and certainly upon our reputation. I am sure that you are aware I am thinking of such things as the grain grading scandals in the Louisiana Gulf area a few years ago and of other charges that the so-called giant multinational grain companies were abusing their economic power. I do find that the press is substantially more interested in carrying the charges on page one than they are on carrying the refutation to the charges at least on page one. I suppose that is a situation not necessarily limited to our industry, but I guess I feel hopeful that we are turning to the point that gradually more and more people are beginning to recognize the viability of the U.S. grain marketing system and their place in it, and our place in it, and we are going to try to do everything we can to continue that.

Pomeranz

I have a simple question; I hope you have a simple answer. Dr. Gilles told us that through the years, consistently, there was more protein in North Dakota spring wheat than in Manitoba. If that is the case, why are we residual sellers?

Kohlmeyer

I think that our experience suggests that Dr. Gilles is right. I think we are not talking about a matter of quality as much as we are about marketing approach. Essentially, the Canadians grow wheat to export, obviously their domestic consumption is only about 10 to 12 percent of their total consumption. Now the United States grows wheat to export as well. The difference is that the Canadians recognize this more strongly than we do. Consequently, the Canadians are not prepared to the extent that there is an available market to carry out export wheat simply because they are unable to get what might be considered an adequate premium for protein. Said another way, they are willing to sell that relatively high protein into the export market at whatever price it takes. There are many examples of this, but I will just mention one. The Canadians, when they sell to Brazil, frequently will ship 13 or 13.5 protein 2 or 3 CWRS. United States competes against that wheat with 11 protein hard winter wheat. The Brazilians will not pay the United States a premium for protein higher than 11, but the Canadians feel compelled to ship it to Brazil because, essentially, that may be all they can ship.

Also, I think there have been some impediments in the nature of government policy in the United States, especially in the last couple of years, which have tended to throw some road blocks into the direction of U.S. wheat exports, and which have given the Canadians an opportunity, as well as some other countries, I might add, to make some sales that otherwise we might have without regard, again, to protein. Perhaps the simplest answer to your question is to say that the Canadians aren't terribly concerned about the protein content of the great majority of wheat they sell to the export market because they know their market isn't concerned.

Unidentified questioner

If our so-called ordinary hard winter wheat contained a high level of protein, wouldn't that fact make it more competitive in export markets with such wheats as Argentine and other origin wheats of low protein?

Kohlmeyer

The answer to that is this: to the market that kind of wheat is pointed at, the most important thing in obtaining the business is 5 cents a ton--not one-half percent in protein. If our ordinary U.S. hard winter wheat can be delivered to a buyer 5 cents a ton cheaper than Argentine Plate wheat, or any other competitive cheap wheat, regardless of quality, given the market that we are talking about, the important factor is not the quality. It is the 5 cents a ton.

Wilda H. Martinez

Do you see the current devaluation of the dollar exerting an influence on wheat exports in the near term and further on 5 years down the road?

Kohlmeyer

To this point, so far this crop year, I don't think I can identify at least any significant amount of wheat business that is approved in the United States because of the devaluating dollar. I might place a small question mark after the business that has been done to the Peoples Republic of China, which, as you probably know, has returned to the U.S. wheat market after having been absent since 1974. I think I would make that question mark very small because in my personal opinion, it is not a factor.

Now there are a couple of reasons for this. For one thing, some areas in the world protect their own domestic agriculture from the slings and arrows of the world market. I am thinking principally of the European Economic Community and Japan. The falling dollar only increases in the case of the European Economic Community, only increases the amount of levy that is added on to export values rather than to increase demand. In the case of Japan, it will probably serve to increase their rice support price practices in spite of the fact that they have a huge surplus of the item. There are other countries that impose trade barriers tending to mitigate against the effect of the cheapening U.S. dollar. I think, however, it is probably too early even this year to draw any final conclusions, and I think it is possible that we may see some export business accrue to the United States this year. Perhaps it is not so

much the case of wheat as feed grains or oilseeds that can be said to be stimulated by the declining U.S. dollar.

As far as a few years down the road are concerned, the opportunity is present for the United States to carve a larger slice out of the export market, as it will exist 3 or 4 or 5 years from now. I consider it as an opportunity. We are going to face stiff competition in the world wheat export market, and I am not convinced that the U.S. government is going to be willing to pursue policies that would be necessary to stimulate our ability to capture some of that increase. I do consider, however, that the world market, particularly in the next 5 years, barring some totally unexpected economic catastrophy, will continue to expand at a rate greater than population growth and, consequently, will represent an excellent opportunity for the wheat producer and everyone associated with the wheat industry.

Unidentified questioner

Would you amplify a little what policies you think work against our ability to increase our share of the export market?

Kohlmeyer

I think where the set-aside program may have some short-term benefits, it has some serious long-range implications that are not particularly good for the long-range health of the U.S. wheat economy. I consider that showing the world we are prepared to take acreage out of production, that we are trying to force it out of production through economic measures at the same time that most of the rest of the world is increasing its wheat acreage, is a dangerous policy. First of all, it casts some doubt on the reliability of the United States as a supplier. And it gives other countries the opportunity to get in on the ground floor of such increase in the world wheat export potential as I perceive there to be. Second, the U.S. government, and quite a number of other governments, are spasmodically in the process of trying to negotiate a new wheat agreement. Those negotiations regretably have been tied in to the general empty end trade negotiations, and I think I see a willingness to, on the part of this Administration, accept a wheat agreement that I would consider to be detrimental to the U.S. wheat economy in the sense that it probably leaves the United States still in the position of carrying a substantial portion of the world's reserves. It does move rather far in the direction of fixed minimum and maximum training prices, which I consider to be economically dangerous. I'd say those are the two principal areas.

I think that I could mention one other area. I don't believe, personally, that this Administration is publicly willing to give the U.S. agriculture economy, and particularly our ability to export agricultural products, nearly enough importance in its public statements. I am not speaking of Secretary Bergland, particularly, but rather of others, because it seems to me that agriculture in spite of its benefits to our economy, as a whole, and the obvious benefits of agriculture exports, is not getting its fair credit for those benefits. I would like to see the Administration do a better job of publicizing agriculture's role in that regard.

Pomeranz

You made the statement that 5 cents per bushel is more important than 5 percent of protein. This has been recently extended to mean that quality is of no consequence. I think that this is exaggerated because, generally, there is a certain understanding as to what quality means when it comes from a certain place. I think that it is taken for granted that certain areas of the world produce and market types of wheat of well defined composition and quality.

Kohlmeyer

Possibly so, but are we speaking now of the chicken or the egg? Let me reverse the question and ask you if you would pay me a half a cent more for that quality? I think, again, the only way I can comment in this regard is to say that I have been in this business for a long time, and I hear a lot of buyers talk about quality, but I see relatively few of them willing to pay the price to be certain to obtain it. I see them willing to buy at the cheapest price available and running the risk of taking potluck on quality.

Unidentified questioner

Isn't this partly because, as time goes on, a greater and greater percentage of the wheat purchased overseas is bought by government purchasing agencies with essentially one criteria for specifications, and so they are shopping?

Kohlmeyer

Well, I would be more inclined to consider that the reasons are essentially economic, and I think that the economies apply whether we are speaking of a government purchasing agency or whether we are speaking of a private purchasing agency. I do agree that in countries where a strong private marketing system exists, and where those countries are able, through their own system, to have individual purchasers be the flour mills or the other users make individual purchasing decisions. In those countries there is probably a greater emphasis paid to quality than when a government bureaucracy is making essentially a budgetary decision.

PRINCIPLES OF WHEAT PROTEIN PRICING

Leonard W. Schruben [1]

At any time protein premium for a completed sale in any market is equal to the price demanded by the most willing seller and offered by the most willing buyer.

Each user will have an established priority, and when premiums are large, a buyer restricts his use of high protein to higher value in use. When premiums are small, he puts high protein to a lower value in use. Thus, a buyer is willing to pay a substantial premium for flour used to satisfy high priority needs and follows a downward premium scale for each successive step down his priority ladder.

In the absence of product discrimination, as is the case of wheat protein, a buyer will procure supplies sufficient for all his needs at one price. That price will determine which supplies can be obtained to meet his lowest includable priority. Although willing to pay a higher price for higher priority uses, he need not and therefore will not do so.

Sellers also face a schedule of values corresponding to the ladder of priorities when flour is put to use. A relatively large supply of high-protein wheat will reach further down on the value in use scale and, to clear the market, will be priced lower than under circumstances where limited supplies will only satisfy needs of a higher order. All sellers must accept the same price if they are to make a sale because buyers need pay no higher price than that offered by the most willing seller.

Thus, in an open competitive market, which is typified by U.S. wheat, wheat protein premiums are established by the lowest use value of any buyer and the retention or reservation price of the most willing seller. Buyers cannot purchase for a lower price and do not need to pay a higher price. Sellers cannot obtain a higher price than the lowest offered by any other seller and need not accept a lower price.

The wheat protein price pattern also reflects the range of substitutability of one protein level for another and one class of wheat for another. Thus, the pricing principle that wheat of a given quality will not fetch a higher price on the market than a buyer is required to pay for a satisfactory substitute. The relative range of substitutability for several uses is substantial as has been depicted in a recent report prepared by the U.S. Department of Agriculture (USDA) (*1*). See figure 1.

---

[1] Agricultural economist, Agricultural Experiment Station, Kansas State University, Manhattan, Kans. 66506.

For example, during years after a large harvest of high-protein hard winters, the usual premium for hard springs narrows because high protein hard winters can substitute in many uses for the hard springs. In some years, when weather adversely affects the quality of the hard springs, the premium may disappear altogether with the opposite reaction in years of small supplies of higher-protein hard winters.

Likewise, when a large supply of high-protein hard winter wheat is available, the premium scale for higher protein at Kansas City may drop to zero (*2*). This supply-demand relationship can be illustrated by reference to the quantity of wheat containing 13 or higher percent protein produced in Kansas and the premium quotation at Kansas City. See figure 2 and tables 1 and 2 (*3*).

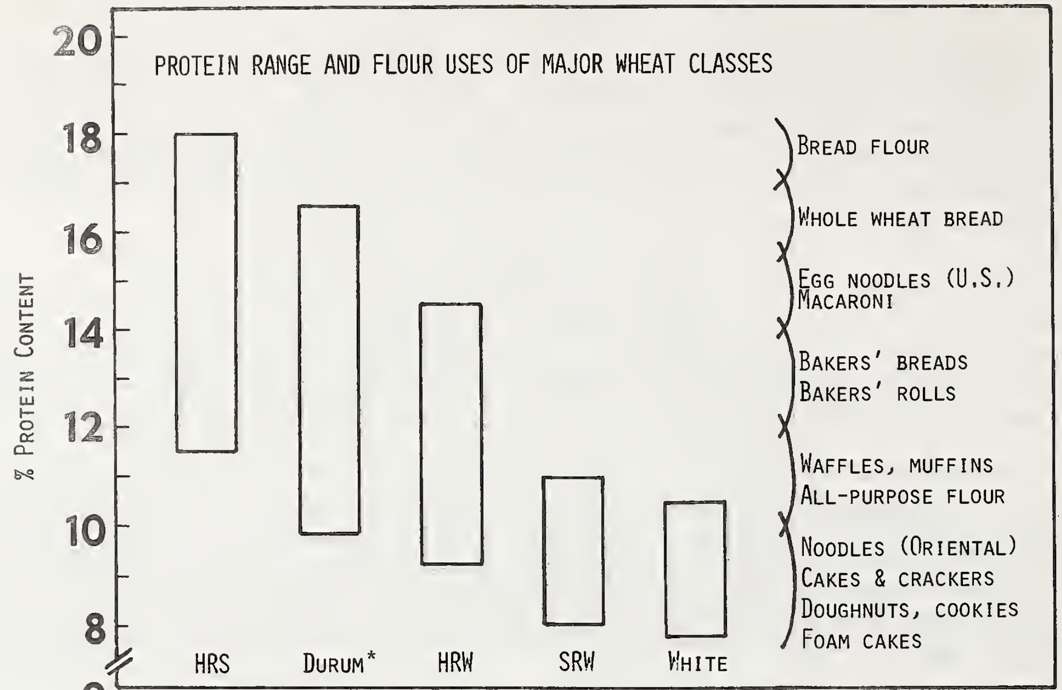
Of the 19 years included, the maximum premium for 13 percent protein over "ordinary" increased or decreased in years after an increase or decrease in production of wheat containing 13 percent or higher protein by a ratio of 15 to 4. This relationship illustrates protein premium levels vary a great deal in relation to the quantity of high-protein wheat available. The higher premiums beginning in 1974 disappeared after the 1977 harvest of increased quantity of high protein wheat.

Another relationship that affects protein premium is the relative availability and size of discounts of low-protein wheats. When these kinds of wheats are available at large price reductions, a mill mix frequently may be less costly if a greater than usual quantity of the high proteins is included in the blend. This relationship indicates why European buyers prefer to import wheats having a higher protein content, given the quality of the domestic product.

The interrelationship between domestic and export pricing can be illustrated by the market reaction to the unsuccessful effort to legislate grain standards relating to color identification in hard red winter wheat in early 1977. Several countries announced they would not consider the purchase of U.S. hard winter wheat where the grade certificate did not include color. The prospects of a reduction in utilization of hard winters and prospective increase in hard springs contributed to an adjustment in the protein premium.

Legislation was proposed by a U.S. senator from a neighboring state as an amendment that would prohibit color analysis of hard winter wheat by the Federal Grain Inspection Service. This would be a "back door" change in federal grading standards. Normally grain standards are changed only after widespread discussion by all parties concerned and not by direct legislation. This was bad legislation apparently designed to help a special-interest group based on ignorance as to how the world wheat market operates. What the senator didn't realize was that the grading system will not be used unless most buyers, as well as sellers, agree that it is fair.

Brazil and some other countries announced they would refuse to buy hard red winter wheat using the proposed grades. Soon after the color amendment was introduced, announcements from at least three countries--Brazil, Colombia, and Chile--indicated they would buy only hard red winter (HRW) wheat that met a minimum color standard.



*Protein content not market factor

Source: U.S. Department of Agriculture

Figure 1.--Ranges of use for U.S. wheat of different types and protein content.

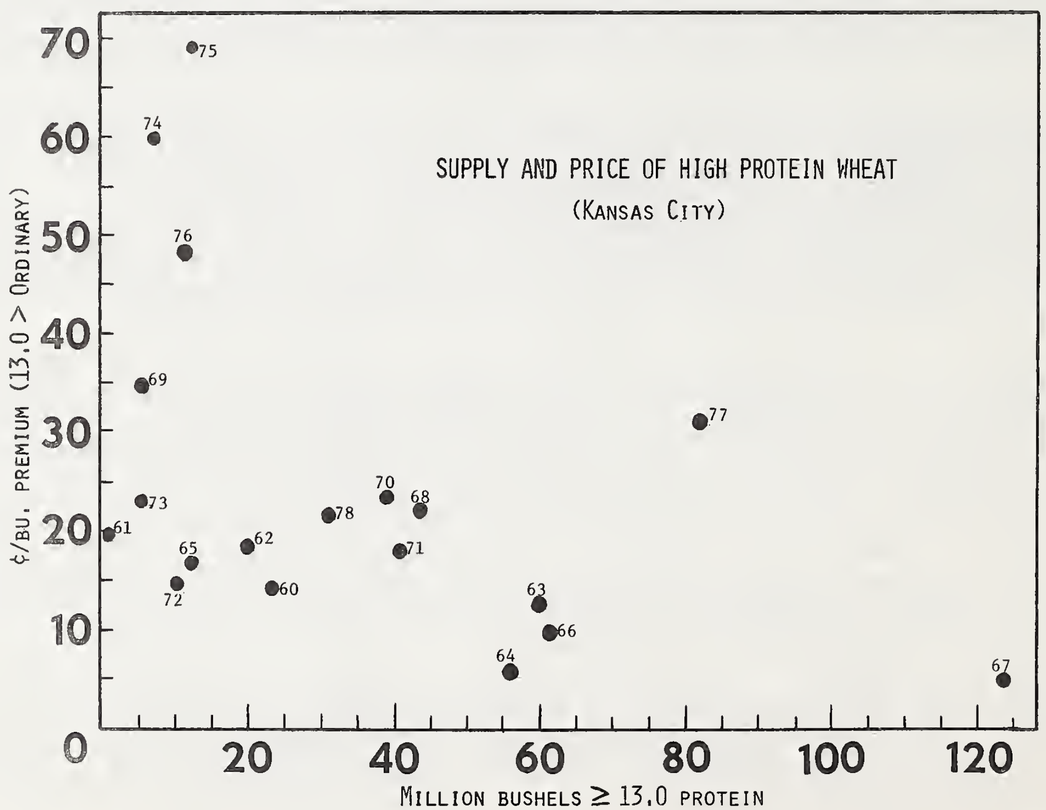


Figure 2.--Relationship between production of high protein wheat and maximum protein premiums (13.0 percent protein or higher).

TABLE 1.--Kansas wheat in various protein ranges

(Percent)

YEAR	UNDER 10.0	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	OVER 14.9	TOTAL
60	7556	67428	129625	62487	20635	2615	290	290640
61	49271	120714	82118	19982	1642	0	0	273728
62	3548	34652	83708	66591	17952	1878	417	208750
63	183	15811	70599	70416	23165	3677	0	183854
64	642	17571	60430	79716	46715	8571	642	214291
65	14689	89382	76933	55272	10207	2489	0	248975
66	1371	16068	50752	64665	45069	14500	1763	195956
67	1378	15527	30106	57914	73312	43665	7813	229820
68	7120	65866	86211	51625	29500	12461	1525	254312
69	30102	125580	113722	28886	4865	912	0	304070
70	6802	76902	118903	55014	34310	3253	591	295779
71	5001	31572	100657	134730	38137	2500	0	312600
72	9585	77610	136050	75446	10203	309	0	309205
73	30106	166921	136814	41539	5335	381	0	381100
74	7526	102233	133593	63660	6272	313	0	313600
75	20706	123890	139420	49004	11388	690	0	345100
76	5566	85791	153574	70729	10805	982	0	327450
77	0	8763	94297	165810	75017	6660	0	350550

(Thousand bushels)

YEAR	UNDER 10.0	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	OVER 14.9
60	2.6	23.2	44.6	21.5	7.1	0.9	0.1
61	18.0	44.1	30.0	7.3	0.6	0.0	0.0
62	1.7	16.6	40.1	31.9	8.6	0.9	0.2
63	0.1	8.6	38.4	38.3	12.6	2.0	0.0
64	0.3	8.2	28.2	37.2	21.8	4.0	0.3
65	5.9	35.9	30.9	22.2	4.1	1.0	0.0
66	0.7	8.2	25.9	33.0	23.0	7.4	0.9
67	0.6	6.8	13.1	25.2	31.9	19.0	3.4
68	2.8	25.9	33.9	20.3	11.6	4.9	0.6
69	9.9	41.3	37.4	9.5	1.6	0.3	0.0
70	2.3	26.0	40.2	18.6	11.6	1.1	0.2
71	1.6	10.1	32.2	43.1	12.2	0.8	0.0
72	3.1	25.1	44.0	24.4	3.3	0.1	0.0
73	7.9	43.8	35.9	10.9	1.4	0.1	0.0
74	2.4	32.6	42.6	20.3	2.0	0.1	0.0
75	6.0	35.9	40.4	14.2	3.3	0.2	0.0
76	1.7	26.2	46.9	21.6	3.3	0.3	0.0
77	0.0	2.5	26.9	47.3	21.4	1.9	0.0

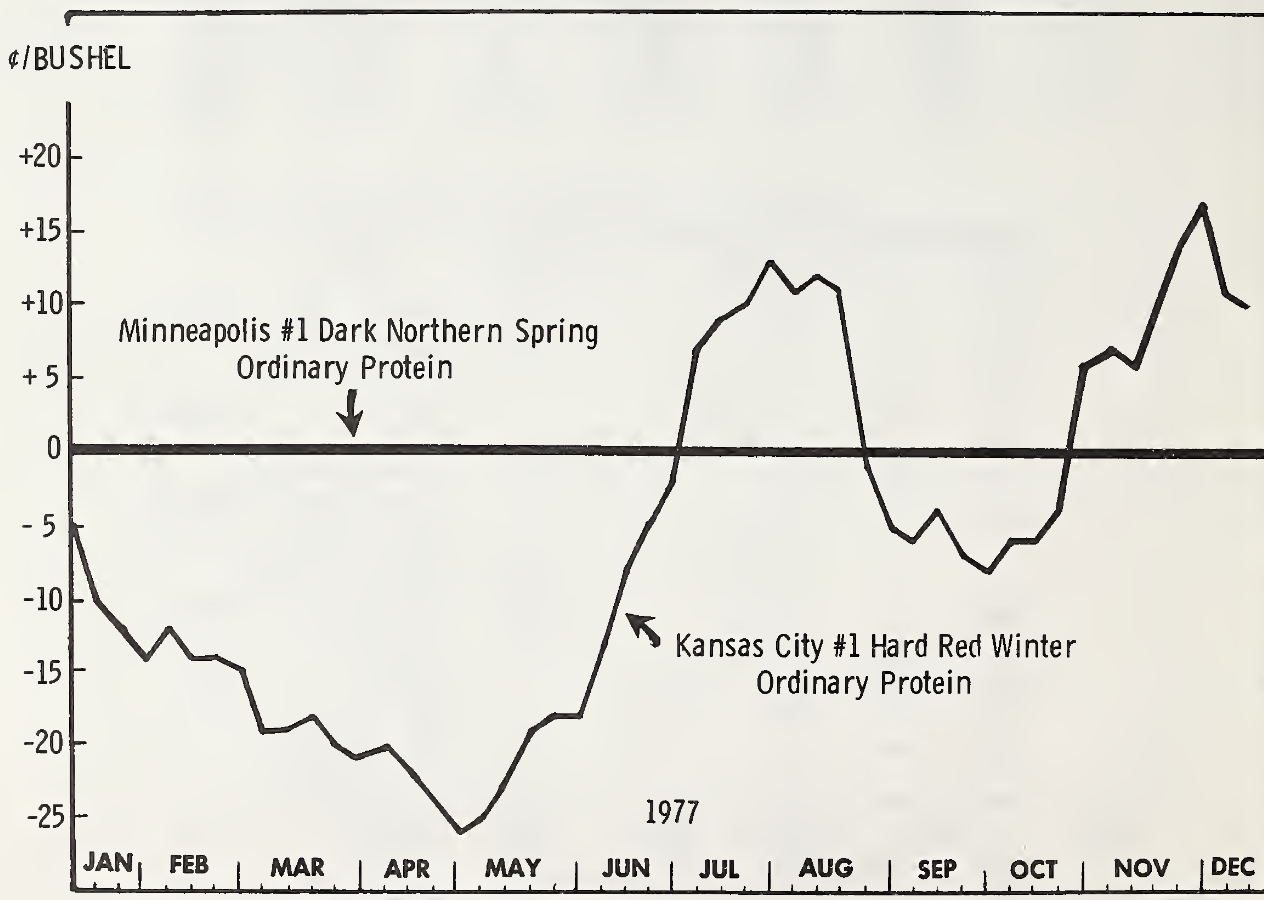
TABLE 2.--Wheat: Difference between low price for ordinary and low price for 13.0 percent premium at Kansas City

Calendar year	High for year	Date(s)	Low for year	Date(s)
1960	+14	7/8-12	+ 2	6/10
1961	+20	7/12	+ 4	1/27-2/9, 3/10-3/29
1962	+18	8/3, 8/23-24	+ 8	12/27-31
1963	+13	2/4-20, 6/25	+ 3	12/10-31
1964	+ 6	7/8-10	0	3/18
1965	+17	7/2-8	+ 1	1/4-2/5, 3/18-23
1966	+10	6/1	+ 2	7/20-8/18, 12/8-22
1967	+ 5	5/10-6/12, 11/10-13	+ 2	3/2-6, 4/4-5/2, 8/22-9/8, 12/1-12/29
1968	+22	10/14-17	+ 1	2/17-29, 3/18-4/5
1969	+35	7/11-15	+16	2/25-3/3
1970	+24	1/5-22	+ 8	10/19-30
1971	+18	1/4	+ 4	8/24-9/9
1972	+15	6/28	0	12/14-15
1973	+23	8/15	0	1/10,3/1, 8/30, 9/13, 11/2, 12/26
1974	+60	9/16	0	1/7, 1/30
1975	+69	6/23-27	+18	8/25
1976	+48	4/20	+18	8/16-17
1977	+31	6/7-10	+ 1	10/18
1978 (to date)	+22	4/17-24	+ 1	3/9-10, 8/22-9/6

The effect of introducing the color legislation in the United States is clearly shown in figure 3. On January 11, the price at Kansas City for dark hard winter wheat was just 5 cents a bushel under the Minneapolis price for comparable dark northern spring wheat. Dark northern spring wheat does not have a color problem and is similar to wheat Canada sells in competition with U.S. wheat.

From this date, USDA's Market News Service reported a steady decline in Kansas City wheat prices compared with those at Minneapolis. On April 26, the difference was 29 cents a bushel. This 24-cent loss occurred as the "color" amendment successfully worked its way through channels in Washington. At this time Congressman Sebelius of Kansas vigorously opposed adding this amendment to the House version of the agriculture bill. After this opposition, the discount soon narrowed to only 19 cents. Later in the year, the color amendment was defeated, and the price at Kansas City advanced to a premium over Minneapolis.

Undoubtedly, the motive of the sponsors was to increase the price of all HRW wheat to the top of the line. But the reverse happened. The price of the top of the line was lowered to match the bottom. This bill didn't help growers who produced lower color quality (yellow berry wheat), and it hurt other producers. Clearly, this is a "no-win" situation for producers, since none of them benefited.



Source: USDA, Market News Service

Figure 3.--Relationship between the price of spring and winter wheat.

This price reaction follows the law of the market that Congress cannot change: Buyers will pay only a price equivalent to value for the poorest quality sellers are permitted to deliver under a contract.

To illustrate, suppose General Motors would allow its customers to order only by naming Cadillac, Buick, Oldsmobile, Pontiac, or Chevrolet. How many people would pay Impala prices, hoping to get a red Chevy Impala when they knew GM could, at its option, send a black Vega?

Henry Ford offered only one color--black. Chevy outsold him by offering a choice of colors. That was 50 years ago, and Ford sales haven't caught up since.

Color isn't of special interest to U.S. buyers. U.S. mills use a protein percentage which is a better test for quality. However, because of the export pricing decision, U.S. mills were able to purchase quality wheat at a discount for awhile. The price-depressing influence was confirmed in a public statement by a mill buyer who reported at the 1977 Kansas Wheat Commission Annual Meeting that domestic flour mills enjoyed at least a 10-cent per bushel reduction in hard red winters during the time this legislation was under consideration.

Preaching to our customers that color isn't important doesn't do any good. If they believe color count is important to them, then it's an important market force. Henry Ford insisted his car ran as well painted black as any other color. But buyers preferred color, and Ford got clobbered.

Wheat protein premiums are variable over time. However, the relationship between size of premium and protein supply is apparent. Forecasting size of the premium could be improved with better basic data and might be worth the effort.

REFERENCES

(*1*) Heid, Walter G., Jr. 1974. Overview of economic forces which determine domestic and world wheat prices. Factors determining the price of white wheat in the Pacific Northwest. Cooperative Extension Service, Washington State University, Pullman. E.M. 3887, November, p. 4-13.

(*2*) The Board of Trade of Kansas City, Kansas City Grain Market Review, Kansas City.

(*3*) Kansas State Board of Agriculture and Kansas Wheat Commission, Kansas Crop and Livestock Reporting Service, Kansas Wheat Quality, Topeka. 1978.

DISCUSSION

Hoover

Seemingly we have come full cycle in this program. I started out by listing the groups that participated in developing this conference. I've tried to weed through the things that I've heard, and I believe that on every issue on protein I have heard both sides stated. We can grow it if you will use it. But there isn't enough being grown even at any price. I don't know what we have accomplished here except the original mission of the groups to have a forum for convening and for sharing our thoughts. I would like to believe that out of this there will grow some continued exchange or active program.

As chairman of this session, it was not my assignment to state where we go from here. The organizing group had no real thrust to present other than to provide a forum for these exchanges of views. Now I would like to open this up, if anyone would like to suggest actions.

Steve Vesecky

I have been here for 2 days, and I feel that we are getting closer together. Our spokesman will tell you or the baking industry will tell you, that we don't want any adversaries and we don't want anybody defending what happened or what didn't happen. We want to cooperate. But I also said something else.

It has been a burning remark in my book ever since the tender age of 29 when Glen Campbell put me in charge of all the buying for the Campbell-Taggart bakeries, which is a pretty big organization. People will say, and have been saying here, if you will pay for it, you can get it. Now let me tell you how Campbell-Taggart buys its flour, and I will bet you that CBA buys its flour the same way.

The first prerequisite for Continental Baking Company, Interstate Brands, or anybody else that is buying flour, is that unless the mill can produce a sample that we approve, qualitywise, we don't even ask them to quote. So don't tell me as a baker that we won't pay for what we want because we don't even let the guys that don't have what we want run in the race! That's the only fair way to do it. Isn't that right? If you're a miller that's the only fair way to do it? If the guy can't produce, you're talking about horses and apples. And I would like to put that across to all of you. We will pay in the baking industry for what we want. And the only people--now I can't speak for every buyer, but I think that I am speaking for the industry--that don't qualify and can't produce what we want, they aren't even asked to get in the race. And if they aren't running, how can they win?

Si Jackel

The bakery representatives present had an opportunity to chat with each other and they thought if the group was willing, it might be appropriate to vote a sense of the meeting sentiment. If it is agreeable with you, I would like to read a few of these sentiments for your possible discussion or approval or disapproval.

The major item is to propose that a follow-up conference be scheduled in 1 year to report progress in achieving wheats of higher protein with superior baking quality to conform with the following statement agreed on by the bakery representatives present. Flour of superior baking quality containing not less than 11.5 percent shall be the near term goal, so the nutritional panel on enriched white breads and rolls may read 8 percent of the U.S. RDA in a 2 ounce serving size, without requiring further supplement with additional protein sources. Some of the characteristics of the superior baking quality that need to be considered are the following factors, with reference to the bakery process operations: mix time, development, uniformity, tolerance, absorption, color, and overall bread score including crumb grain, texture, body, and acceptability. I don't know how you wish to proceed, but this is the major proposal of the several that we have.

Hoover

As I understand it, Dr. Jackel, this is suggested as a guideline. The only real number in this proposal is a short-term goal of not less than 11-½ percent protein in flour, and that these other characteristics would need to be spelled out during an interim year, perhaps by a group of bakers and millers. Isn't that correct? Because this body, as convened, has no authority, I would ask that this be accepted for putting into the transcript, and merely a consensus, if there is one, for the need for further communication by a conference a year from now. In the meantime, work on the sort of suggested guides from the baker groups, is that correct? Would anyone like to comment on this suggestion or proposal?

Virgil Johnson

Tell us again what the objective of the conference a year from now would be. Then I will comment.

Jackel

It is a review of the progress in achieving what the reasons were for this conference in the first place, mainly a perceived need by the baking industry of the deterioration and the flour quality and protein level being offered to it by the milling industry.

Johnson

That is a commendable objective for the conference. But from the standpoint of those of us in wheat breeding and variety improvement, I think the interval is too short. I doubt whether any one of us wheat breeders would have very much new to report 1 year from now that we haven't talked about at this time.

Pomeranz

There is a way of communicating between you and us in the USDA through the liaison committee between bakers and USDA. This is done annually, and it is being reviewed. This meeting is open to everyone. Representatives of universities and research groups always participate in these meetings. A suggestion was made at the last meeting in Berkeley that wheat growers and plant breeders

be invited to participate in the meetings. This would accomplish best the kind of communication that was discussed here.

Vesecky

A good part of our discussion--the bakers meeting of the AIB, all legal minds--was that really our only communication with the plant breeders, generally speaking, is once a year at the Wheat Quality meeting. And we think that there should be more communication not to tell you what to do but to try to assist you and let our views be known so we don't wait 5 years before we say, well, forget it if we can't even live up to the label on a loaf of bread.

We don't have to meet every week. We don't expect you at all. I'm not a plant breeder. I've had only six hours of agronomy, but I know you welcome somebody to point directions that they see down here on the marketplace. The information you gave us indicated, and so did Karl's, that we are going down hill.

Johnson

There is a problem in the marketplace. My point in discussing our regional experimental plots was to demonstrate to you that the trend toward lower protein does not result from breeders backing away from the quality concept. Today's wheat varieties, in addition to being more productive, possess better baking quality and the genetic potential for amount of protein fully equal to that of old varieties.

Vesecky

I don't think you plant breeders have to be on the defensive at all. There is something that is being lost between your stand and where I am, and I don't know what it is. I don't think you know what it is. So what we need is more communication so we understand each other. The only way we're going to solve this problem is with guys like you, Si Jackel, Stan Titcomb, and me. We've got to depend on you. Now all we want to do is help.

Hoover

Let me suggest this as a course of action. Dr. Pomeranz is right in saying that there is a liaison committee of American Bakers Association to the U.S. Department of Agriculture. There is the opportunity in both the Spring Wheat Quality Council meeting and the Hard Wheat Quality Council meetings for an exchange of ideas. Perhaps we should have a continuing small committee based here that would consider the appropriate time to hold another conference. Maybe 2 years is better.

In the meantime, I think there is a good deal of work that should be done perhaps by the technical representatives in the milling and baking industry to further define the various quality factors, not just protein as guidelines for plant breeders and others in the marketplace. I think that group could convene under the auspices of the American Institute of Baking or some other organization. The problem that we have is the knotty one, as I see it. While our intentions and purposes are noble and technical of having a group of bakers,

and perhaps millers, set up a series of recommendations for flour quality, for all of the reasons that we know are good, could be misconstrued as trading standards and thus become pricing factors. This could be viewed as collusion by the Federal Trade Commission. We have a dilemma here that needs to be recognized. While our purposes are to provide a better quality of raw material for the baker to, in turn, provide a consistent good quality product to our customers, we could be treading on dangerous ground. We must have our lawyers look at the formation of such a committee.

How do you feel about having an interim group work out suggestions as guidelines furthering the communication toward holding another conference of this kind, perhaps here or at some other location?

John Shellenberger

I would be inclined to suggest that we have fewer meetings than we have at the present time rather than more. To my dismay, this meeting was held approximately 3 weeks after an international cereal and bread conference in Winnepeg. These international meetings are held about every 5 years. There are sessions on baking technology, which are attended by people from all over the world, as well as those in plant breeding programs, and many sessions deal with proteins. What we need is more work and less meetings.

Vesecky

Let me explain. Let's say bakers have a group, and we want a way to communicate not only with the miller and the cereal chemist but also with the plant breeder. You don't have to call a big conference together to tell you what you think.

Hoover

We have a forum for that already. Both the spring wheat and the hard red winter region have quality councils through which millers, bakers, breeders, and the others are meeting once a year. It seems to me that we have the opportunity by that route to deal with this subject rather effectively.

Vesecky

Well we do, but you have to get smaller groups. I know what John Shellenberger is talking about. If you get a ballpark full of people, you are never going to come to any decision. Maybe we should, in our wheat quality meetings, set aside an hour or two so this is all we talk about. I don't think it would take an hour, but we have to have the right people. Now you people are always available, Dr. Pomeranz, but the bakers are not always there.

Hoover

I agree it is a matter of communication. I was very concerned that about a year ago there was a meeting at which bakers expressed great concern about the increase in mixing time in newly developed varieties. You had an excellent opportunity to voice that concern here for the record. But not a single word was said. Why didn't the bakers speak up? Why wasn't it put in the record. Complaining is not the basis for good communication. Instead, bring it up before the forum.

George Schiller

I think I would like to summarize what I've heard the last few days. I get the feeling listening to what's happened here that there is a problem with the bakers. They feel that the protein quantity and quality have deteriorated over the years in some of the figures that were given. By the same token, we listen to plant breeders. We have done their testing, and I am convinced that the technical expertise to develop the kind of wheat varieties that are necessary to satisfy the bakers is there. I am convinced that we don't lack in this area.

Now, what I would like to do is to second the idea of better communication, if there is a breakdown between plant breeders and bakers that consumes this flour. Somebody in between isn't reading somebody else's needs right, for whatever the reason, whether it is technical, economical, or some other. I am convinced that all the ingredients necessary to get satisfied customers are already out and have been talked about.

What I think we need to do is go forth with the idea. Let's talk about this thing in some manner that we can resolve our differences. I think those differences are real. I think that you are basically looking at something that you don't like, but I am not at all convined that it can be solved in a way some bakers may be suggesting. There are new methods; there are new ingredients, and there are a lot of other things we can do. I think the communication problem is the big one.

Vesecky

We don't need anymore ingredients. We've got more than we know what to do with. What we want is flour that will do it. That is the bakers' goal. We don't want to get a maze of chemicals to make this thing work.

Hoover

Let's see if we can extract this much out of this discussion. There has been a charge from many sources worded in different ways that this group, which acted as convenors of this conference, should continue to consider other ways of communication. We are going to publish these proceedings as quickly as possible and those of you who attended will receive a copy. I do think that a small group should be organized to develop more definitive flour quality guidelines.

GPO 823-845-8

UNITED STATES DEPARTMENT OF AGRICULTURE
Science and Education Administration
North Central Region
.S. Grain Marketing Research Laboratory
1515 College Avenue
Manhattan, Kansas 66502

OFFICIAL BUSINESS
Penalty for Private Use $300

POSTA
U.S.
AGRICULTURE
AGR 101

U.S.MAIL